SPECIAL ISSUE

JANUARY 2022

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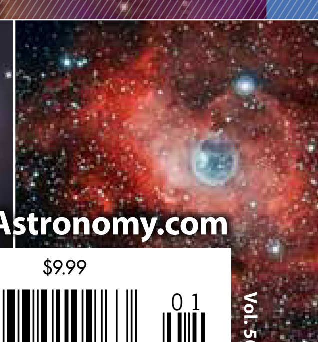
101 MUST-SEE COSMIC OBJECTS

THE BRIGHTEST, MOST SPECTACULAR, STRANGEST, AND MOST CHALLENGING — A LIFELONG LIST!







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0 74666 01096 3 01

Vol. 50 · Issue 1

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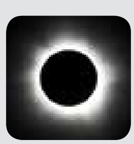

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Astronomy (ISSN 0091-6358, USPS 531-350) is published monthly by Kalmbach Media Co., 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Periodicals postage paid at Waukesha, WI, and additional offices. POSTMASTER: Send address changes to *Astronomy*, PO Box 8520, Big Sandy, TX 75755. Canada Publication Mail Agreement #40010760.

FROM THE EDITOR

A hobby of lists

The Dumbbell Nebula, the first recognized planetary nebula, highlights an all-star list of cosmic delights.
GEORGE CHATZIFRANTZIS

When in 1774 the French comet hunter Charles Messier began listing fuzzy patches of light in the sky, wanting to separate them from the comets that interested him, he started quite a trend. His list of Messier objects — originally 45 targets, eventually expanded to 109 — constitutes the most famous of the checklists that provide backyard astronomers with a rounded survey of celestial delights.

But Messier's list is hardly the only such compilation. For instance, dedicated deep-sky observers know the *New General Catalogue*, assembled by J.L.E. Dreyer in 1888 and expanding on work done by the Herschels. It contains a whopping 7,840 galaxies, clusters, and nebulae, and two additions, the *Index Catalogues*, add another 5,386 objects. These lists, coupled with a dark sky and a moderate-sized telescope, offer literally a lifetime of cosmic targets to enjoy.

For this special issue of *Astronomy*, I devised my own list of 101 "must-see" objects. Yes, our favorites are here: the Orion Nebula, the Andromeda Galaxy, the Pleiades, the Hercules Cluster. And some of the standout NGC objects missed by Messier should not be missed by anyone else. They include the Rosette Nebula, the Owl Cluster, Stephan's Quintet, and the Veil Nebula.

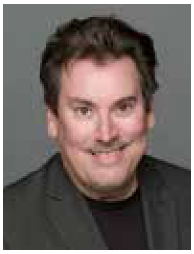
Far-southern objects outside of the purview of Charles Messier's Parisian latitude are also included. Be sure not to miss the Magellanic Clouds, Omega Centauri, the Southern Pleiades, and the Coalsack Nebula. Star clusters, nebulae, and galaxies do not entirely make up the list; stars are here too. See Alpha and Proxima Centauri, Albireo, and Mizar and Alcor, to name a few.

I also included some really exotic, ambitious targets: There is the first black hole ever confirmed, Cygnus X-1, and distant galaxy clusters like the Hercules and Coma galaxy clusters. A rare galaxy/quasar pair, NGC 4319 and Markarian 205, offers a challenge even in large backyard scopes.

And the list goes on. I hope you'll enjoy this special issue and keep it handy if the attraction from magical things to see in space, hanging far out away from us, ever begins to subside.

Yours truly,

David J. Eicher
Editor



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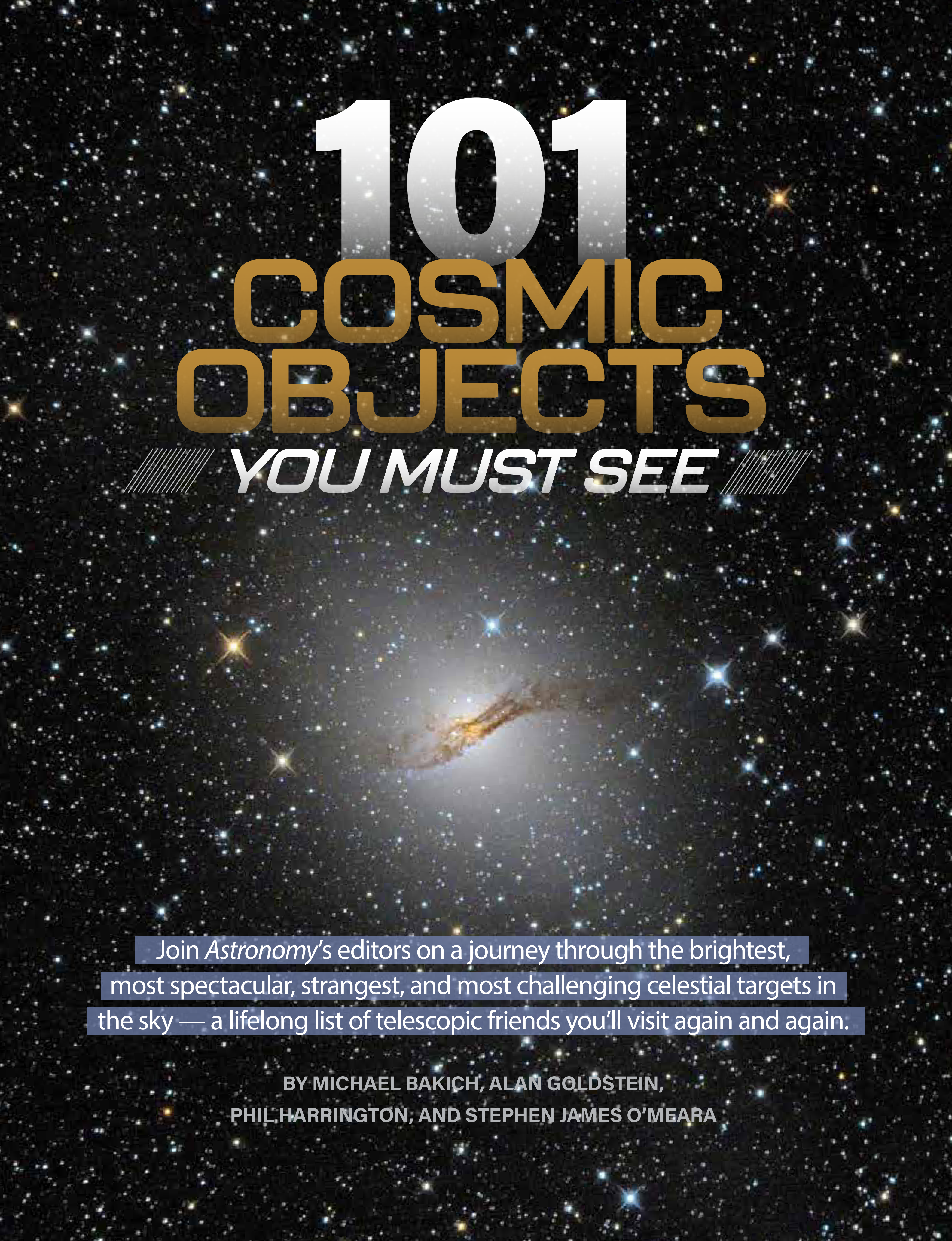


101 COSMIC OBJECTS YOU MUST SEE

Join *Astronomy*'s editors on a journey through the brightest, most spectacular, strangest, and most challenging celestial targets in the sky — a lifelong list of telescopic friends you'll visit again and again.

BY MICHAEL BAKICH, ALAN GOLDSTEIN,
PHIL HARRINGTON, AND STEPHEN JAMES O'MEARA

1 Centaurus A ←

Centaurus A (NGC 5128) is a standout object for Southern Hemisphere observers. NGC 5128 is often called the Hamburger Galaxy because of the two regions of stars (the bun) that surround a dark dusty lane (the burger). And it's a heck of a meal: A mere 12 million light-years away, Centaurus A has a diameter of about 60,000 light-years.

Scottish astronomer James Dunlop discovered NGC 5128 in 1826 using a 9-inch reflecting telescope in his observatory in Parramatta, New South Wales, Australia. Astronomers gave it the catalog name Centaurus A because it was the first radio source discovered in the constellation.

Both NGC 5128's appearance and its radio emission have their roots in a galactic collision. The main body of Centaurus A — a giant elliptical galaxy — is absorbing a smaller spiral galaxy. The two objects collided more than 200 million years ago, creating large regions of star formation. This collision also probably aided the growth of the supermassive black hole in the center of the galaxy. Current estimates of its mass put it in the range of 55 million times that of the Sun.

To find NGC 5128, aim your telescope 4.5° due west of magnitude 3.5 Mu (μ) Centauri. Through small scopes, the galaxy appears round with a wide dark lane cutting it in half. This lane gets wider on both ends. Through 14-inch or larger instruments, you should see a thin wedge of light shining through the lane's western end. — M.B.

GABRIEL SANTOS

KFIR SIMON

2 The Bug Nebula ↑

Amateur astronomers named the Bug Nebula (NGC 6302) for its insectlike shape. But because the Bug's apparent size is only 2', that shape is all they saw. Recent pictures taken with the Hubble Space Telescope have revealed much more detail. Now NGC 6302 is often called the Butterfly Nebula.

Whatever name you give it, NGC 6302 is on a number of top 10 lists — no surprise, considering its visual magnitude of 10.1 makes it one of the brightest planetary nebulae known. It's also among the most massive. And its central star has a surface temperature greater than 450,000 degrees Fahrenheit (250,000 degrees Celsius), making it one of the hottest stars in the universe.

That central star, by the way, wasn't discovered until 2009. Astronomers didn't detect it because it's so hot that most of its output is ultraviolet radiation, which the surrounding cloud of gas absorbs and then reemits as visible light. The lack of visible light coming from the star, coupled with its bright surroundings, made spotting it difficult. It wasn't until astronauts installed the Wide Field Camera 3 onto Hubble that researchers finally saw it.

American astronomer Edward Emerson Barnard discovered NGC 6302 through a 5-inch refractor in 1880. The planetary lies some 3,400 light-years away in the constellation Scorpius. To find it, point your telescope 3.9° west of magnitude 1.6 Shaula (Lambda [λ] Scorpii).

If you observe NGC 6302 through an 8-inch telescope with an eyepiece that magnifies between 50 and 100 times, it looks like a galaxy that stretches east-west and is four times as long as it is wide. At powers above 150x, you'll be able to see the two lobes on either side of the core. The one on the western side is easiest to see. It has a tapered end. The faint arm to the east is a more difficult catch. — M.B.

3 The Southern Cross ↓

CHIRAG UPRETI

With the possible exception of the Big Dipper, the Southern Cross ranks as the sky's most familiar asterism (a recognizable group of stars that is not a constellation). Indeed, its three brightest stars are among the 25 brightest in the whole sky. This stellar pattern is so famous that five countries depict it on their flags: Australia, Brazil, New Zealand, Papua New Guinea, and Samoa.

Mariners plying southern waters have used the Southern Cross as a direction marker for centuries. Its long axis points to the South Celestial Pole, which is handy because, unlike in the Northern Hemisphere, no bright star lies anywhere near that spot. Specifically, a line drawn from magnitude 1.6 Gacrux (Gamma [γ] Crucis) through magnitude 0.8 Acrux (Alpha [α] Crucis) and extended 25° will lead an observer close to the South Celestial Pole.

Officially, the Southern Cross is the constellation Crux, a star pattern picked out by early European explorers. Crux ranks as the smallest of the 88 constellations, covering a paltry 68.45 square degrees. That area is only 0.166 percent of the sky. Because it contains several bright stars, however, it tops the list in terms of overall brightness, which is the number of visible stars in a constellation divided by the constellation's area in square degrees. That value for Crux is 29.2, far surpassing the second-place finisher for overall brightness, Corona Australis, which has a value of 16.4. — M.B.

MICHAEL STECKER

5 The Cone Nebula ↓

The Cone Nebula (NGC 2264) and its associated open cluster, the Christmas Tree Cluster, is in the faint constellation Monoceros the Unicorn. The easiest way to find it is to point your telescope 3.2° south-southwest of magnitude 3.4 Xi (ξ) Geminorum. At magnitude 3.9, the cluster glows brightly enough for you to spot with your naked eyes, albeit as an indistinct fuzz ball. It lies some 2,700 light-years away and measures about 7 light-years across.

With an eyepiece that yields a magnification of 50x, you'll see 10 to 15 stars to the east and west of 15 Monocerotis, which glows at magnitude 4.7. This line forms the ½°-long base of the tree. Note that while its top points to the south, the tree may seem upside down to you, depending on your scope's optical configuration. The stars south of the line may appear to make the tree's top, but they're not actually moving through space with those in the main cluster. They only happen to lie in the same direction.

At the southern end of the Christmas Tree Cluster is the Cone Nebula. This dark nebula is a cloud of dust and cold gas with a conical shape. And while the cluster is easy to spot with your eye, the nebula is not for observers. Instead, it's astroimagers who capture it quite easily, superimposed on the brighter emission nebulosity behind it. The emission nebula's crimson glow results from a two-part process: Its hydrogen first absorbs ultraviolet radiation from the intensely hot star 15 Monocerotis (the brightest star in the Christmas Tree Cluster), then reemits it as red light.

To see the Cone Nebula, you'll need a large amateur telescope at a dark site. A 14-inch or larger scope might show a strip of nebulosity about 5' long that originates at the brightest star and proceeds to the west. This gas belongs to the emission nebula Sharpless 2–273, which stretches an additional 2° to the west. —M.B.

4 Barnard's E ↑

Barnard's E has to be one of amateur astronomers' all-time favorite binocular objects. This combination of two dark nebulae (Barnard 142 and Barnard 143) comes from American astronomer Edward Emerson Barnard's catalog of such objects.

The E lies against the rich Milky Way in Aquila. Start at yellow-hued magnitude 2.7 Tarazed (Gamma [γ] Aquilae). If you center Tarazed, you shouldn't have to move your binoculars at all. Barnard's E lies 1.6° west-northwest of the star.

Barnard 143 (often designated B143) is the easiest of the two to spot. Its most visible part is a narrow bar about 15' long, which stretches east to west. A second dark bar of the same length connects at its east end and heads northward. The end of that bar is the start of a third one, which parallels B143. The combination of these three bars forms a U-shape whose open end points to the west.

Just to the south of B143 lies Barnard 142 (B142), which also parallels its northern counterpart. This dark bar isn't quite as distinct as B143, making it more difficult to see.

Astronomers classify the clouds that form Barnard's E as dark nebulae. These objects, which will become future star-forming regions, are composed of dust and cold gas. Really cold gas: The temperature of the hydrogen in dark nebulae is always within about 10 degrees of absolute zero. If it were warmer than that, the atoms within the cloud would be moving too fast to merge together when they collide, and stars would never form.

Dark nebulae give off no light of their own and they don't reflect light from nearby stars. The only way we see them is if they lie in front of bright backgrounds. Barnard's E lies closer to us than the Milky Way behind it. If you view it through binoculars from a dark site, you'll see it silhouetted before many tens of thousands of unresolveable stars. —M.B.

PATRICK A. COSGROVE

6 The Rosette Nebula

Observers and astroimagers usually think of the magnificent Rosette Nebula as a single deep-sky object. But actually, this combination of a star cluster and nebula has five separate entries in the *New General Catalogue*: NGC 2237, NGC 2238, NGC 2239, NGC 2244, and NGC 2246. And although they all lie within the constellation Monoceros the Unicorn some 5,200 light-years away, they weren't all discovered at the same time.

The beautiful open cluster NGC 2244, which lies at the center of the nebulous complex, was found by English astronomer John Flamsteed in 1690. Then, in 1830, John Herschel discovered the first nebulous region, NGC 2239. Next up was NGC 2238, discovered in 1864 by German astronomer Albert Marth. To complete the picture, American astronomer Lewis Swift discovered NGC 2237 in 1871 and NGC 2246 in 1885.

You won't have any problem seeing NGC 2244. If your observing site is dark, a 4-inch telescope will reveal 25 stars in an oval region that stretches northwest to southeast. It's a bright oval, too. Six of the stars are brighter than 8th magnitude. Move up to an 11-inch scope, and the background star count will surpass 100. Whichever scope you choose, start with an eyepiece that has a true field of view between ½° and 1°.

Two things will help you observe the four nebulous regions that surround NGC 2244: low power and a nebula filter. A magnification around 50x will give you a wide field of view, and the filter will dim the cluster's stars. — M.B.

BERNARD MILLER

SERGEY TRUDOLYUBOV

7 NGC 7331

Deep-sky objects have some creative nicknames, but what's up with the Deer Lick Group? In the 1980s, amateur astronomer Tom Lorenzin was observing in the mountains of North Carolina, at the Deerlick Gap Overlook. Because his view of NGC 7331 and its surrounding galaxies was so memorable, he christened them the Deer Lick Group.

William Herschel discovered NGC 7331 in 1784. This galaxy is a pure spiral, nary a bar in sight. It lies in the constellation Pegasus the Winged Horse about 4.4° north of 3rd-magnitude Matar (Eta [η] Pegasi).

The Deer Lick Group contains four other galaxies: NGC 7335 (magnitude 13.4), NGC 7336 (15), NGC 7337 (15.2), and NGC 7340 (14.9). In comparison, NGC 7331 glows at magnitude 9.5. But these fleas, as they are called, aren't actually fainter or smaller than the main galaxy. They're simply much farther away.

While NGC 7331 lies about 40 million light-years from Earth, the four other members are between 290 million and 370 million light-years away. So, calling this gathering a group is correct only in an apparent sense. In fact, none of the fleas are even gravitationally bound to each other.

From a dark observing site, most observers can spot NGC 7331 through 50mm or larger binoculars. An 11-inch telescope and a magnification of 200x will reveal a bright core surrounded by a soft glow three times as long as it is wide. You'll also just barely see three of the fleas as an equilateral triangle east of the main galaxy. — M.B.

8 The Pleiades ↑

Visible to the unaided eye as a tiny congregation of stars due west of Taurus' V-shaped head, the Pleiades (M45), also known as the Seven Sisters, is one of the sky's premier open star clusters. Under typical suburban skies, you might be able to count five or six stars set in the shape of a tiny dipper. Move to darker skies, though, and that number could double or even triple.

One reason the Pleiades puts on such a grand show is because it is only about 445 light-years away. That makes it one of the closest clusters to Earth. Just how many stars belong to the Pleiades depends on the source you quote. Some will say about 200, while others will claim more than 1,000. Studies suggest that Pleiades' stars are roughly 100 million years old — mere infants compared to the Sun.

Photographs of the Pleiades show they are immersed in blue reflection nebulae. Originally, astronomers believed that the nebulosity was leftover material from the cluster's formation. Recent studies, however, show that the nebulae and the cluster are moving through space at two different velocities, proving these objects are independent and just happen to be currently passing each other on their separate journeys through the cosmos.

The Pleiades spans nearly 2°, making binoculars and wide-field telescopes best for taking in the view. There are several striking binary and multiple stars within M45. The star Atlas, shining at magnitude 3.7, together with Pleione, which varies in brightness from magnitude 4.8 to 5.7, form a wide pair that marks the eastern-pointing handle of the shrunken dipper's bowl. Asterope is also a wide pair of stars, while Alcyone, the brightest Pleiad, is a quadruple star system.

Given an exceptionally clear evening, look closely for soft gossamer wisps of the dust surrounding some of the Pleiades' brighter stars. The brightest portion of the cluster's nebulosity is identified as NGC 1435 and sits near Merope, the southeastern star in the Pleiades' bowl. — P.H.

TIM LOCKHART

9 The Blinking Planetary

Here's an object that's a lot of fun to show to others at summer and fall star parties. Through 8-inch and smaller telescopes, the Blinking Planetary (NGC 6826) in Cygnus appears to blink when viewed with direct, and then averted, vision.

To find this nebula, point your telescope 1.4° east of the magnitude 4.5 star Theta (θ) Cygni. This planetary nebula measures 25" across and glows at magnitude 8.8. It lies some 2,000 light-years away.

The first observers to record this effect were American astronomers James Mullaney and Wallace McCall at Allegheny Observatory in Pittsburgh. They wrote in August 1963 about the effect, which they saw while using the observatory's 13-inch Fitz-Clark refractor.

More recently, astronomers studying images of the Blinking Planetary have identified two slightly fainter spots on either side of the nebula. Christened Fast Low-Ionization Emission Regions (FLIERs), they are clouds of gas moving away from the central star much faster than the planetary's shell. They're a bit fainter because high-energy ultraviolet radiation from the star, which ionizes the gas in the expanding shell, doesn't have the same effect on the gas in the FLIERs. The higher density of these regions probably accounts for this difference.

With a medium-sized scope and using direct vision, you'll spot the 11th-magnitude central star easily, but the nebula won't be visible. Use averted vision and look just a bit to the side of the star, and the nebula pops into view. Not only that, its apparent brightness under averted vision swamps the star's light. So, by looking back and forth with averted and then direct vision, you can make this object blink. It takes some practice, but the result is quite fun.

The best way to see this effect is from a dark site with a 6-inch scope and a magnification of about 100x. Do note that if you use too large a scope, the brightness of the nebula will overwhelm the star and you won't see the blinking effect. — M.B.

10 NGC 6781

Planetary nebula NGC 6781 lies in the constellation Aquila the Eagle. But while this star figure ranks 22nd in size among the 88 constellations, you won't find any Messier objects or emission nebulae in it. In fact, although it sits squarely within the Milky Way, it contains few even reasonably bright star clusters.

NGC 6781 doesn't make up for all that, but it is a fine target for amateurs with medium-sized telescopes. This interesting planetary lies some 3,500 light-years away and is about 2 light-years in diameter. Like all such objects, however, the bubble continues to expand and will do so until it's too far from the central white dwarf for the star's radiation to ionize it. At that point, it simply will fade from view.

To find NGC 6781, aim your telescope 3.8° north-northwest of magnitude 3.4 Delta (δ) Aquilae. What you'll see is an almost perfect bubble of gas cast off by a star that once generated energy like our Sun, but which has long since stopped fusing hydrogen into helium within its core.

Through a 6-inch telescope at 100x, magnitude 11.4 NGC 6781 stands out well against the rich, star-filled background of Aquila. Through larger instruments, you'll see that the disk doesn't have a sharp edge and is slightly oval-shaped. If the seeing (atmospheric steadiness) at your observing site is good, you'll notice that the central region of the nebula is darker than its surroundings.

If you're able to observe this planetary through a 14-inch or larger scope, you'll see lots of structure in its thick ring. At high powers, you'll spot small, dark blotches across its face. The planetary's central star, now a slightly bluish white dwarf, glows weakly at magnitude 16.2, so don't spend too much time searching for it. — M.B.

RONALD BRECHER

ADAM BLOCK/MOUNT LEMMON SKYCENTER/UNIVERSITY OF ARIZONA

JOHN CHUMACK

11 The Coma galaxy cluster

As you might guess, the Coma galaxy cluster resides within the boundaries of the constellation Coma Berenices. If you have access to a large amateur telescope, you can search for it 2.7° due west of magnitude 4.2 Beta (β) Comae Berenices.

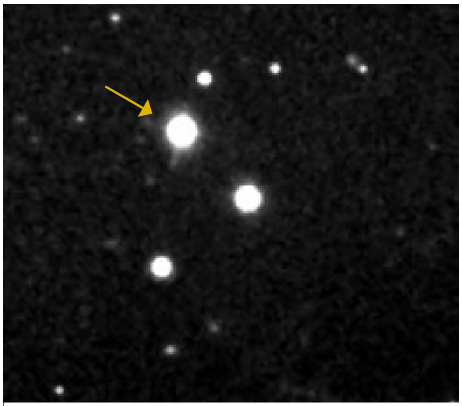
The Coma Cluster is huge, with over 1,000 galaxies within a 4°-wide field. The richest area, however, is the central 0.5°, a region that covers as much sky as the Full Moon.

This cluster's designation is Abell 1656, taken from American astronomer George O. Abell's catalogs. His original list contained 2,712 clusters in mostly the northern sky. An extension (after his death) covering the far southern sky brought the total number to 4,073 galaxy clusters.

Because this cluster lies some 330 million light-years away, not every galaxy in it is going to be a standout. What's more, this cluster is dominated by elliptical galaxies that show few details. So, if you can view through a 12-inch or larger telescope from a dark site, at least try to identify the brightest members.

Four galaxies glow brighter than 12th magnitude: NGC 4884 (magnitude 11.5), NGC 4889 (11.5), NGC 4793 (11.6), and NGC 4874 (11.7). Five surpass 13th magnitude: NGC 4789 (magnitude 12.1), NGC 4839 (12.1), NGC 4921 (12.2), NGC 4911 (12.8), and NGC 4827 (12.9). If you start with a good finder chart of the region, you should be able to identify several dozen more by using these nine galaxies as starting points.

The Coma Cluster has an invisible claim to fame. In 1933, Swiss astronomer Fritz Zwicky was studying the motions of galaxies within Abell 1656. He concluded that the galaxies he could see were revolving around the center of the cluster 400 times faster than they should be, based on the visible mass of the cluster. He called the unseen mass dark matter. — M.B.



STEVE WALTERS

12 3C 273

Observers love looking at distant objects — and the farther, the better. Well, how about an object that's more than 2 billion light-years away and visible through an 8-inch telescope? 3C 273 is that object. It's a quasar: a superluminous active galactic nucleus.

At the center of the celestial wonder sits a supermassive black hole that weighs in at about 1 billion solar masses. This behemoth has lots of gas around it. As the gravity from the black hole pulls the gas in, it forms a swirling disk. A huge amount of energy is then generated by friction and other forces in the disk.

Quasars are the most luminous objects in the universe, and thus visible across vast distances. The brightest known quasar, 3C 273 also has the distinction of being the first quasar ever identified.

3C 273 lies in the constellation Virgo the Maiden. It appears starlike and glows softly at magnitude 12.9. A good star chart, however, will allow you to quickly identify it. Begin your search 4.7° northwest of magnitude 2.7 Gamma (γ) Virginis.

Astronomers can't determine the distance to 3C 273 directly, so they infer it by measuring its redshift, which is the amount its light is stretched due to its motion away from us. The greater the redshift, the more distant the object is. 3C 273 has a redshift of 0.158, which corresponds to a distance of 2.443 billion light-years.

Let's close with a number that properly demonstrates the stunning brightness of 3C 273: The object is 3.99 trillion times as bright as our daytime star. — M.B.

13 The Crescent Nebula

The Crescent Nebula, which lies in the constellation Cygnus the Swan, has plenty of names. Among them are NGC 6888, Caldwell 27, Sharpless 2–105, and LBN 203. Whatever you call it, this object is a fascinating bubble of gas being carved out of the interstellar medium by the winds of an intensely hot star named WR 136.

As this high-velocity wind hits a slower-moving stellar wind that the star previously produced when it became a red giant, the collision produces a shock front and the shell of gas we see: NGC 6888. The interaction is so energetic, in fact, that it also produces X-rays.

The Crescent lies some 5,000 light-years away and measures about 25 light-years across. It glows at magnitude 7.4. That seems like a healthy number (just below naked-eye visibility); however, the nebula's size (0.3° by 0.2°) really cuts down the surface brightness. You'll begin to see some of the structure through an 8-inch telescope. But, honestly, it takes an 11-inch or larger instrument to begin to do it justice.

To find NGC 6888, point your telescope 1.2° west-northwest of the magnitude 4.8 star 34 Cygni. Or, if you want to start with a brighter star, aim 2.7° southwest of magnitude 2.2 Sadr (Gamma [γ] Cygni).

The slightly curved northwest edge is the brightest, but a short line of bright nebulosity also sits at the southwest edge. Larger telescopes will show a thick nebulous patch that runs from the westernmost edge to the central star. You'll see WR 136 easily. It shines at 7th magnitude and lies at NGC 6888's center.

An Oxygen-III filter really helps to bring out the contrasting sections of this object. This filter also increases its overall visibility by dimming the vast number of background stars that are part of the Milky Way running through Cygnus. — M.B.

JOHN CHUMACK

14 Leo I

As the name implies, Leo I resides in the zodiacal constellation Leo the Lion. This deep-sky target is a great example of a dwarf spheroidal galaxy. Such objects are faint, have little dust, and are not forming new stars. Usually, they are found as satellites orbiting larger galaxies — more than 30 of the 59 confirmed satellites of the Milky Way are dwarf spheroidal galaxies.

Leo I lies approximately 820,000 light-years away, which makes it the fourth most distant satellite of our galaxy. It has a diameter on the order of 2,000 light-years and a mass of

TONY HALLAS

15 NGC 4565 →

Observers love looking at face-on spiral galaxies. There's something captivating about seeing a disk of light with a concentrated core and magnificent sweeping arms containing millions of stars suspended in your eyepiece. But edge-on spirals offer an alternative view, and some observers enjoy them just as much. The finest example in the sky is the Needle Galaxy (NGC 4565), discovered by William Herschel in 1785.

NGC 4565 lies in the constellation Coma Berenices, 3° southeast of magnitude 4.3 Gamma (γ) Comae Berenices. It is the second brightest member of the Coma I Group, which contains some two dozen galaxies and may include up to 20 additional members. The center of this group lies approximately 47 million light-years away.

The Needle Galaxy glows at magnitude 9.6 and is easily visible through an 8-inch or larger scope. It's not precisely edge-on because its plane inclines about 3.5° to our line of sight, but it's close enough. Images show its length-to-width ratio is about 8-to-1, but visual limitations mean the object will appear five times longer than it is wide.

The center of the galaxy appears to be a small bulge. Recently, astronomers used the Spitzer Space Telescope to study the Needle at infrared wavelengths. They discovered that its central bulge is box shaped, meaning that its not actually a bulge, but a bar.

At high powers, you might detect the dust lane running along NGC 4565's entire length. It's easiest to pick out against the core. If you're using at least a 14-inch scope, look ¼° west-southwest for one of the Needle's companion galaxies, NGC 4562. At 14th magnitude, it's a tough catch.

One final note of caution: If you're star-hopping to this galaxy rather than using a go-to drive, don't confuse the Needle Galaxy with the Silver Needle Galaxy (NGC 4244). That object lies 12.5° to the north-northwest and is in the constellation Canes Venatici the Hunting Dogs. — M.B.

SERGEY TRUDOLYUBOV

DAN CROWSON

16 The Hercules galaxy cluster ←

For observers who own or have access to large telescopes and a dark viewing site, one of the most impressive sights in the sky is the Hercules galaxy cluster. Also known as Abell 2151, this group of galaxies takes the term *deep sky* to a whole new level. It lies at the astounding distance of 500 million light-years.

If your scope has a go-to drive, its database may not contain Abell galaxy clusters. Instead, just target this cluster's brightest member, elliptical galaxy NGC 6047. Without a go-to, first find magnitude 5.0 Kappa (κ) Herculis. From that star, move 1° northwest and your field of view will land on hundreds of galaxies, most of which glow too faintly to see. But that still leaves several dozen within the range of moderate amateur instruments. Around half of all the members in the Hercules Cluster are spirals. And several of those galaxies are in the process of merging.

Seven members of Abell 2151 are brighter than 14th magnitude, although three just barely crest that level: NGC 6047 (magnitude 13.5), NGC 6061 (13.6), IC 1194A (13.6), NGC 6055 (13.7), IC 1185 (13.9), NGC 6045 (13.9), and NGC 6056 (13.9). Of these, NGC 6045 is the most interesting visually because of the magnitude 15.5 lenticular galaxy PGC 84720 that lies at its eastern tip. The pair gives most the impression of a hockey stick or the letter L.

To successfully observe this galaxy cluster, use at least a 12-inch telescope and magnifications in excess of 250x. High magnifications increase the contrast between extended objects like galaxies and the background sky. Because Abell 2151 spans more than 1°, you'll need to move your scope around a bit to see the maximum number of galaxies, especially when observing at high power. — M.B.

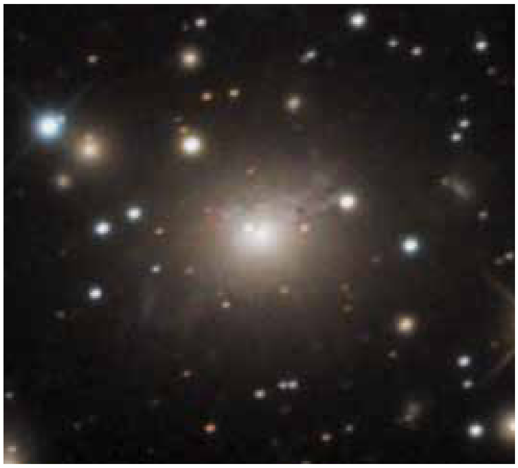
roughly 25 million Suns. American astronomer Albert George Wilson discovered it in 1950 while examining a photographic plate taken by the 48-inch Schmidt camera at Palomar Observatory.

Astronomers think Leo I may be the youngest of the Milky Way's dwarf spheroidal galaxies. None of its stars seem older than about 10 billion years, and most of them formed between 2 billion and 6 billion years ago. And no stars (or only an extremely small number) have formed in the past billion years. That may be because around a billion years ago, Leo I made its closest approach to the Milky Way. Our larger galaxy's gravitational influence may have stripped away all the gas available to create stars.

Although Leo I is easy to find, it's not all that easy to observe. To locate it, point your telescope 20' north of magnitude 1.3 Regulus (Alpha [α] Leonis). Unfortunately, the glare from that star (especially if the humidity is high) can mask the subtle glow of Leo I, which has a magnitude of 11.2. That dim light is further reduced, spread over an area measuring 10' by 7'.

The best strategy is to place Regulus just outside the field of view to the south. Start with a low-power eyepiece and increase the magnification to get the best view. — M.B.

17 NGC 1275 →



DAN CROWSON

NGC 1275, often referred to as Perseus A, is the brightest member of the Perseus galaxy cluster. It lies roughly 225 million light-years away and has a diameter of slightly more than 100,000 light-years. The *A* part of its designation means the object is a strong source of radio emission.

NGC 1275 is considered a Seyfert galaxy. Each member of this class of active galaxies has a brilliant quasarlike nucleus, but not so bright that it drowns out the rest of the galaxy.

In addition to being a strong radio source, NGC 1275 is also a strong emitter of X-rays. The source of this radiation is the center of the galaxy, where a supermassive black hole with a mass some 800 million times that of the Sun gorges itself on gas. The friction and other forces produced by the gas as it spirals into the black hole generate X-rays.

The Perseus galaxy cluster, also known as Abell 426, is part of the Pisces-Perseus Supercluster. This chain of galaxy clusters stretches more than 40° across the sky. To find the Perseus galaxy cluster, look 2° east of Algol (Beta [β] Persei). Through a large amateur telescope, several of its galaxies — all ellipticals — appear bright, small, and nearly circular. Don't confuse NGC 1275 with NGC 1272, a similar galaxy just 5' to the west. NGC 1272 is ever-so-slightly brighter.

Through a 10-inch telescope, you'll spot a dozen galaxies in a field of view 1° across. Most lie south and west of NGC 1275. Here's a region of sky where increased aperture really pays off. As you look through larger telescopes, you'll see more galaxies, and the ones you've already spotted will show a bit more detail — as much as ellipticals can show, anyway. — M.B.

18 Barnard's Galaxy ↓

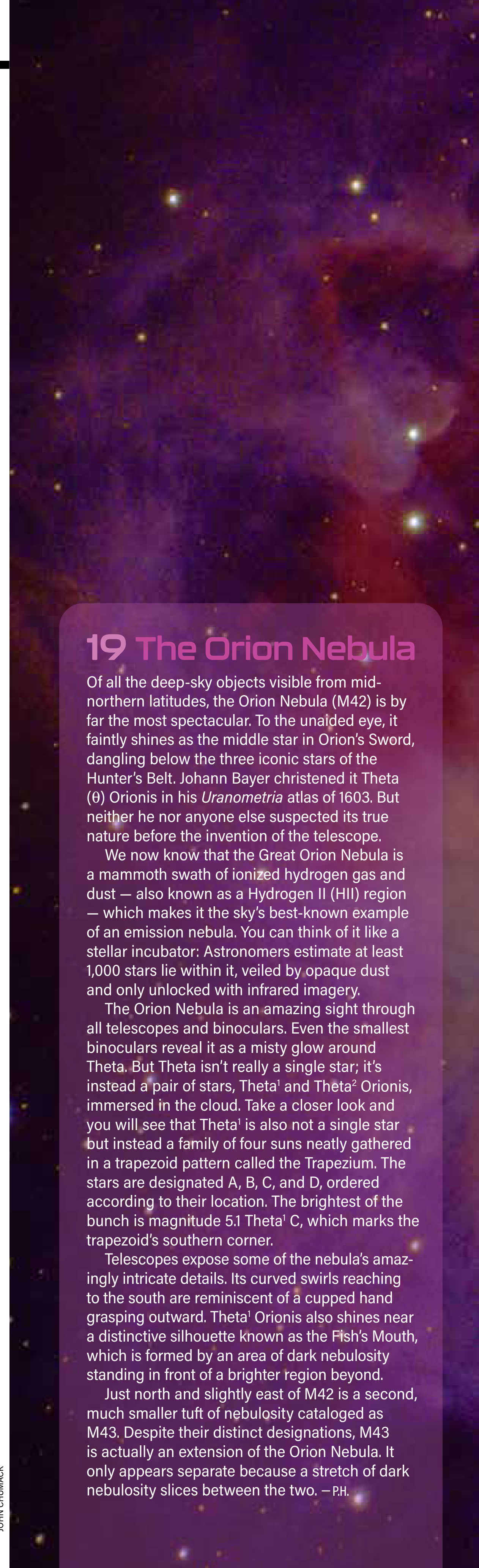
Barnard's Galaxy (NGC 6822) was discovered by American astronomer Edward Emerson Barnard through a 6-inch refractor in 1881. You'll find this object in Sagittarius, 1.5° north-northeast of 5th-magnitude 55 Sagittarii.

NGC 6822 is an example of a dwarf irregular galaxy. Barnard's Galaxy was the first galaxy beyond the Magellanic Clouds for which astronomers calculated a distance. In 1925, American astronomer Edwin Hubble used Cepheid variable stars within it to estimate its distance at 700,000 light-years. The current best number, however, is 1.5 million light-years.

NGC 6822 glows softly at magnitude 8.1 — which is actually pretty bright for a galaxy. Unfortunately, that light spreads out over an area 16' by 14', which is 30 percent the area of the Full Moon. That makes its overall surface brightness low. So, whichever telescope you use, start with the eyepiece that gives you the widest field of view. You're looking for a dim haze roughly twice as long as it is wide.

Large scopes will let you see several star-forming regions at the northern end of the galaxy. The best way to spot them is through a 14-inch or larger scope used in conjunction with a nebula filter. Without a filter, look for a slightly brighter streak of stars along the galaxy's long axis. You might even see some single supergiant stars — these are recognizable by the grainy appearance they lend the galaxy. — M.B.

JOHN CHUMACK



JOHN CHUMACK

19 The Orion Nebula

Of all the deep-sky objects visible from mid-northern latitudes, the Orion Nebula (M42) is by far the most spectacular. To the unaided eye, it faintly shines as the middle star in Orion's Sword, dangling below the three iconic stars of the Hunter's Belt. Johann Bayer christened it Theta (θ) Orionis in his *Uranometria* atlas of 1603. But neither he nor anyone else suspected its true nature before the invention of the telescope.

We now know that the Great Orion Nebula is a mammoth swath of ionized hydrogen gas and dust — also known as a Hydrogen II (HII) region — which makes it the sky's best-known example of an emission nebula. You can think of it like a stellar incubator: Astronomers estimate at least 1,000 stars lie within it, veiled by opaque dust and only unlocked with infrared imagery.

The Orion Nebula is an amazing sight through all telescopes and binoculars. Even the smallest binoculars reveal it as a misty glow around Theta. But Theta isn't really a single star; it's instead a pair of stars, Theta^1 and Theta^2 Orionis, immersed in the cloud. Take a closer look and you will see that Theta^1 is also not a single star but instead a family of four suns neatly gathered in a trapezoid pattern called the Trapezium. The stars are designated A, B, C, and D, ordered according to their location. The brightest of the bunch is magnitude 5.1 Theta^1 C, which marks the trapezoid's southern corner.

Telescopes expose some of the nebula's amazingly intricate details. Its curved swirls reaching to the south are reminiscent of a cupped hand grasping outward. Theta^1 Orionis also shines near a distinctive silhouette known as the Fish's Mouth, which is formed by an area of dark nebulosity standing in front of a brighter region beyond.

Just north and slightly east of M42 is a second, much smaller tuft of nebulosity cataloged as M43. Despite their distinct designations, M43 is actually an extension of the Orion Nebula. It only appears separate because a stretch of dark nebulosity slices between the two. — P.H.

MICHAEL STECKER

20 NGC 6231 ←

Look toward the southern region of Scorpius and you'll encounter what seems to be a brilliant comet. The head of this asterism, known as the False Comet, is the spectacular NGC 6231. This is the sky's sixth-brightest open cluster, an object often called the Northern Jewel Box because of its resemblance to the Jewel Box Cluster (NGC 4755; see #40) in the southern constellation Crux. NGC 6231's apparent diameter is 15', half that of the Full Moon, and it lies some 5,500 light-years away.

Italian astronomer Giovanni Battista Hodierna discovered NGC 6231 in 1654 and included it on a list of nebulous objects that observers might misinterpret as comets (just as Charles Messier had 120 years later). This object shines so brightly, however — at magnitude 2.6 — that skywatchers earlier than Hodierna certainly noticed it.

The area from Zeta (ζ) to Mu (μ) Scorpii contains a group of young blue stars called the Scorpius OB1 association. To our eyes, some 20 members appear more luminous than 9th magnitude. Up close, they would be blinding. The brightest stars of the Northern Jewel Box put out 60,000 times more light than the Sun.

Although this cluster is an easy naked-eye target that stands out well even from the surrounding Milky Way star field, binoculars will reveal half a dozen lesser open clusters nearby. When you finish glancing at those, point a 4-inch telescope back at NGC 6231 and you'll see more than 100 stars strewn across its ¼°-wide diameter. Crank up the power and look at the center of this object for a tight grouping of stars that outshine the others. — M.B.

21 The Saturn Nebula →

The Saturn Nebula (NGC 7009) is a planetary nebula in the constellation Aquarius the Water-bearer. While to a casual viewer its common name may seem misplaced, it comes from the thin lobes on either end of its disk. These projections, called *ansae* (Latin for "handles"), make this nebula look like Saturn, complete with rings, in large scopes. The ansae are actually gas that the nebula has ejected in opposite directions. This fascinating object lies some 5,000 light-years away.

The Saturn Nebula resides slightly more than 1° west of the magnitude 4.5 star Nu (ν) Aquarii, or just slightly southeast of the midpoint of a line from magnitude 2.9 Sadalsuud (Beta [β] Aquarii) to magnitude 3.1 Dabih (Beta Capricorni).

Because NGC 7009 glows at magnitude 8, it's easy to observe through an 8-inch or larger telescope. Your best chance to unlock some details is to use magnifications above 200x — or at least the highest that sky conditions at your observing site allow.

First, try to spot the central star. This magnitude 11.5 point of light sits at the center of NGC 7009. Once a hydrogen-fusing sun like our own, the star is now a white dwarf.

Once you find the central star, take a look at the overall shape of this planetary, which definitely appears oval. The long axis of the disk spans 25'. Each ansa protrudes from the disk another 2'. If you are viewing through a 14-inch or larger scope, examine the ends of the ansae and look for slightly fainter round regions. — M.B.

DAN CROWSON

FERNANDO OLIVEIRA DE MENEZES

22 The Tarantula Nebula ←

One of the sky's standout objects is the Tarantula Nebula, also known as the True Lovers' Knot, Caldwell 103, and 30 Doradus. At the center of this HII region (a cloud of ionized hydrogen) is the massive open cluster NGC 2070. It's the central group of ultrahot stars in this cluster that produces the ultraviolet radiation that makes the nebula glow.

It's too bad that most amateur astronomers living in the Northern Hemisphere haven't observed the Tarantula Nebula. Although it lies 160,000 light-years away in the Large Magellanic Cloud (see #80), this object looks great through any telescope. Sporting a true diameter of more than 1,800 light-years, the Tarantula would appear some 25° across if it were as close as the Orion Nebula (M42; see #19). At that distance, its overall brightness would top that of Venus, and it would even cast shadows.

NGC 2070 is a young open cluster some astronomers categorize as a super star cluster. Such objects are brighter and more massive than the run-of-the-mill open clusters we see elsewhere. But it's really the central 16 light-year-wide region of NGC 2070 that stands out. Listed in the *Radcliffe Observatory Magellanic Clouds Catalogue* as R136, this is an amazing starburst region. Many of its 72 stars are among the most massive, brightest, and hottest stars known.

R136 is easy to spot through a 4-inch scope as a 1'-wide region. The same instrument will reveal a few gaseous loops and filaments in the nebula. The longest starts at the cluster's center and stretches 7' to the south. Then it curves east and finally northward. Look to the east of R136 for two easy-to-see dark bays. — M.B.

23 M83 →

The Southern Pinwheel Galaxy is a celestial treat for those who can see it. This galaxy measures 14' by 13'. M83 also is bright at magnitude 7.5, making it the eighth-brightest galaxy in the sky. Its distance certainly plays a factor in both of these traits; the Southern Pinwheel Galaxy lies a mere 14.7 million light-years away.

Using a ½-inch refractor, French astronomer Nicolas Louis de Lacaille discovered M83 in 1752. Charles Messier added it to his now-famous catalog in 1781.

M83 is the second-brightest member of a collection of more than a dozen galaxies called the Centaurus A/M83 group. As you may have guessed, the other notable (and slightly brighter) object in this group is Centaurus A (NGC 5128; see #1). Gravitational interaction in the past billion years between M83 and the nearby dwarf irregular galaxy NGC 5253 has triggered considerable star formation in each.

Despite so many galaxies in one area, M83 lies in a region of the night sky short on bright stars. The nearest reasonably bright star, 1 Centauri, glows at magnitude 4.2 and lies 3.7° south-southeast. Alternatively, you can find M83 9° northwest of magnitude 2.1 Menkent (Theta [θ] Centauri). From a dark site, the galaxy is pretty easy to sweep up using binoculars.

The Southern Pinwheel Galaxy appears nearly face-on, so you'll see its spiral structure through telescopes with apertures as small as 6 inches. The core is petite and round, and the bar extends to the northeast and southwest. Through 12-inch and larger scopes, you'll see large clumps of stars and star-forming regions along its arms. — M.B.

MAICON LOPES NUNES

BERNARD MILLER

24 NGC 3532 ↓

If you love common names for deep-sky objects, NGC 3532 in the constellation Carina the Keel will give you all you want. Various amateur astronomers through the years have called it the Firefly Party Cluster, the Football Cluster, the Wishing Well Cluster, the Pincushion Cluster, and the Black Arrow Cluster. More formally, it's also listed as Caldwell 91 and Melotte 103.

No matter how you refer to it, this fabulous open cluster sits in a gorgeous star field 4.7° south-southwest of magnitude 3.9 Pi (π) Centauri. You'll see it immediately without optical aid because it glows at 3rd magnitude and it spans 55'. The 150 or so stars NGC 3532 contains, however, are too faint to see individually (averaging approximately magnitude 7.5), so the impression is of a bright glow within the Milky Way.

French astronomer Nicolas Louis de Lacaille discovered NGC 3532 in 1751 through his ½-inch refractor. It was one of many discoveries he made from the Cape of Good Hope in South Africa with this instrument.

A 4-inch telescope with an eyepiece that yields a magnification of 100x will reveal more than half of NGC 3532's stars. Back off the power a bit, and you'll see several dark lanes between clearly delineated lines of stars. Go for an even wider field of view and numerous colorful stars will pop into view past the cluster's tightly packed core. A blue and a deep red one lie at the cluster's northeast end. The blue star is SAO 238839; its red counterpart is SAO 238855.

A bit of interesting trivia connects this cluster with the Hubble Space Telescope. On May 20, 1990, NGC 3532 became the first target imaged by Hubble's Wide Field and Planetary Camera. Well, not the entire cluster — the shot captured a region of sky near the magnitude 8.4 star HD 96755 that measured only 11" by 14", which is a minuscule 0.006 percent of the area occupied by the whole cluster. — M.B.

FERNANDO OLIVEIRA DE MENEZES

25 NGC 2516 ←

NGC 2516 is an open star cluster in the southern constellation Carina the Keel. Amateur astronomers refer to it as the Southern Beehive because of its resemblance to M44 (see #94), the open cluster in Cancer the Crab. It lies some 1,300 light-years away and has an apparent diameter of 30', similar to that of the Full Moon. Various teams of astronomers have estimated its age at between 110 million and 135 million years.

French astronomer Nicolas Louis de Lacaille discovered it in 1751, using a ½-inch refractor. That may not seem like a large scope, but such an instrument gathers 3.3 times as much light as a fully dark-adapted human eye. And that increase in light-gathering power was just enough to allow Lacaille to find objects either too faint for the eye or just dense enough that the eye can't quite resolve them into stars.

To find this spectacular cluster, look 3.3° west-southwest of magnitude 1.9 Avior (Epsilon [ε] Carinae), the southwestern star in the asterism known as the False Cross. Because NGC 2516 glows at magnitude 3.8, you'll have no trouble spotting it with your naked eyes — it's one of the sky's 20 brightest open clusters.

If you point a 6-inch telescope at this cluster, you might be able to count 75 stars, but it won't be easy. That's because the stars fall into two brightness ranges. The upper range starts with SAO 250055 — a magnitude 5.8 red giant, making it the cluster's brightest star — and includes those members brighter than magnitude 8. To see the lower range of stars, crank the power beyond 250x to spread the bright stars out. If you don't, their light will hide the many faint stars within the cluster. When using high power on NGC 2516, you'll come across several double stars (and even one triple star) whose brightness straddles the line between the two classes. — M.B.

26 Mizar and Alcor →

For most people living in the Northern Hemisphere, the first double star we notice is Mizar (Zeta [ζ] Ursae Majoris), the middle star in the Big Dipper's handle. Located just to the northeast is Mizar's faint cohort, Alcor (80 Ursae Majoris). Mizar shines at magnitude 2.3, while Alcor is magnitude 4. The pair are separated by 11.8', which is resolvable with the unaided eye if the sky is dark enough and your eyesight is good enough. In ancient times, some cultures even used these stars as a test of visual acuity.

Alcor and Mizar are not true physical companions, however. Alcor is 82 light-years away, while Mizar is 83 light-years distant. That's close, but not close enough to form a true binary star. They do, however, share a common direction and speed through our galaxy. Both Alcor and Mizar, as well as the Dipper stars Merak (Beta [β] Ursae Majoris), Phecda (Gamma [γ] Ursae Majoris), and Megrez (Delta [δ] Ursae Majoris) — and about 100 others — form a loose star cluster called the Ursa Major Moving Group.

Although Alcor is not Mizar's real partner, one look at Mizar through a telescope will reveal it as a binary star, a fact discovered by Italian astronomer Giovanni Riccioli in 1650. Studies have since shown that Mizar A and Mizar B are both binaries themselves, bringing

KIM QUICK/TERRY HANCOCK

ALAN DYER

the total star count of the Mizar system to four. Alcor is a binary system, too, accompanied by a 9th-magnitude red dwarf partner set just 1" away.

Through a telescope, you might also notice a faint star forming a broad triangle with Alcor and Mizar. In 1722, German mathematician Johann Liebknecht thought he saw that star move against the background from one night to the next. He concluded that it was a new planet. In his excitement, he christened it Sidus Ludoviciana (Ludwig's Star) after Ludwig V, then the king of Germany. Liebknecht was mistaken, but the star still retains that name. —P.H.

27 Omega Centauri ↑

The most glorious of all globular clusters is Omega Centauri. (NGC 5139 is its more mundane designation.) It's the 24th-brightest "star" in Centaurus, which is the ninth largest of 88 constellations. It was noted in Ptolemy's *Almagest* in A.D. 150 and designated Omega (ω) by Johann Bayer in his 1603 *Uranometria*. Edmond Halley is credited for first noting its non-stellar appearance in 1677. Scottish astronomer James Dunlop first described it as a globular cluster in 1826.

At –47° in declination, Omega Centauri is a challenge for observers at mid-northern latitudes. But it is bright enough at its apex of 6° above the horizon for observers to catch it from 38° north latitude.

For amateur astronomers located far enough south that the cluster is high in the sky, Omega Centauri makes the rest of the globulars look like pale imitations. Its apparent diameter is 36.3' — larger than the Full Moon! It's bright, too, at magnitude 3.9. Northern Hemisphere observers' best and brightest globular is M13 (see #69): magnitude 5.9 and a mere 20' in diameter.

Omega Centauri is resolvable in small telescopes, where other bright globular clusters look like fuzzy balls. A behemoth among the Milky Way's swarm of globulars, it contains 10 million stars (with a total mass of 4 million Suns) crammed in an area 150 light-years in diameter. M13 is 600,000 solar masses by comparison. Omega Centauri is the second most massive globular cluster in the Local Group. Only M31's Mayall II is heftier.

Imagine yourself as an astronomer near the core of this cluster, where the stars are only 0.1 light-year apart. Night would look like day. The relative motions of individual stars would be traceable over a few years. Such a sky sounds like the realm of science fiction.

Where does such a massive globular cluster come from? Astronomers believe Omega Centauri is all that's left of a dwarf galaxy gobbled up by the Milky Way. Most of this galaxy has since been integrated into ours. Kapteyn's Star, 13 light-years away, is likely one such former member. —A.G.

28 The Horsehead Nebula

One of the most prized telescopic dark nebulae is the Horsehead Nebula in Orion. Its widespread popularity comes from photographic images, not its visual impact at the eyepiece. This magnificent celestial bust of a horse's head — like a knight chess piece — is one of the most challenging objects of its kind, especially owing to its diminutive size (5') and low-contrast surroundings.

Scottish astronomer Williamina Fleming discovered the Horsehead Nebula in 1888 while scanning photographic plates at Harvard College Observatory. Edward Emerson Barnard, who imaged it in 1913, said, "This object has not received the attention it deserves," and listed it as his 33rd object in his catalog of dark nebulae. The nebula has ever since been known as Barnard 33 (B33), which, unfortunately, like the dark cloud that it designates, obscures the light of Fleming's find.

We see the dark Horsehead Nebula only because it stands out against the diffuse glow of emission nebula IC 434. Both objects belong to the Orion B molecular cloud, which is one of the largest star-forming regions near our Sun, some 1,300 light-years distant. The Horsehead itself measures some 4 light-years tall and 3 light-years wide, and is part of a larger cosmic landscape hundreds of light-years across that includes the Great Orion Nebula (see #19). If we could sweep away the dense dust covering the Horsehead, we'd find untold stars on the verge of being born.

To find the Horsehead, first locate IC 434. This long reef of dim nebulosity runs for more than 1° southeast of Alnitak (Zeta [ζ] Orionis), the easternmost star in Orion's Belt. Search for a tiny notch of darkness halfway down the sharp and straight eastern fringe of IC 434. Its appearance in small telescopes is one that looks more like a faded thumbprint than a horse's head. Low power helps to concentrate IC 434's glow, which increases contrast and aids in finding the dark notch. The nebula has been spied through telescopes as small as 4 inches and has even been seen through handheld binoculars using an H-beta filter. —S.J.O.

FERNANDO OLIVEIRA DE MENEZES

MATT DIETERICH

29 M104 ↑

Dust is a common component of spiral galaxies. Astronomers believe this dust is carbon- or silicate-rich and no larger than 0.25 micron wide. It doesn't dramatically affect the brightness of galaxies except in cases where they appear nearly edge-on; then, their orientation catches the maximum amount of dust. The Sombrero Galaxy (M104), named for its resemblance to the famous wide-brimmed Mexican hat, is easily the brightest edge-on galaxy with a prominent equatorial dust belt.

It is not *exactly* edge-on, but at 6° off, it's very close. That 6° tilt allows us to see the nuclear region and makes the asymmetrical starry hub visible above and below the dark lane. A bright core contains a massive but quiet black hole with a billion solar masses.

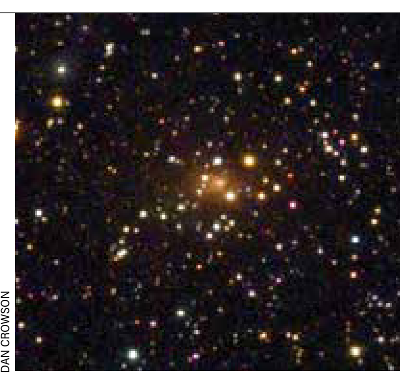
M104 was discovered by Pierre Méchain in 1781. He relayed the information to his observing partner, Charles Messier, who added it to his list of non-cometary objects. But the comet observer's more detailed thoughts on this and other higher-number objects in his list weren't known until French astronomy-popularizer Camille Flammarion published Messier's notes in 1921.

Designated NGC 4594 in John Dreyer's *New General Catalogue of Nebulae and Clusters of Stars*, this 9th-magnitude galaxy is classified as type Sa, noted for having a large central hub in relation to its spiral arms. The arms are tightly wound and lack large HII regions. With dimensions of 8.7' by 3.5' at 29 million light-years distant, the Sombrero has a diameter of about 50,000 light-years — half the size of our home galaxy.

For observers who have never seen a dust belt in a galaxy, M104 is a great first target because it's observable with modest telescopes. Under good skies, it is within reach of a 6-inch telescope. With increasing aperture, more detail is visible along the edge of the dark lane and the bright core becomes better resolved. Try observing this object with multiple apertures at a star party.

The Sombrero is easy to find, just 11° due west of Spica (Alpha [α] Virginis). It's located in Virgo — but barely, as it sits slightly north of the border with Corvus and northeast of Eta (η) Corvi. — A.G.

30 Maffei 1 →



DAN CROWSON

Although galaxies appear throughout the sky, they are not spread evenly. They are found in small groups and larger clusters, and can be as close as the dwarf galaxies that orbit the Milky Way or as far away as the best telescopes can detect.

There is also a swath of sky where galaxies are few and far between. Pioneer galaxy observer Edwin Hubble called this the Zone of Avoidance. It is so named because the vast amount of stars, dust, and gas of the Milky Way's plane overwhelm or block the feeble light of other galaxies.

But while these galaxies' visible light is easily absorbed, their infrared light can penetrate the dust. Italian astronomer Paolo Maffei photographed the sky using a Schmidt camera with infrared-sensitive film in 1967. He found two fuzzy patches in Cassiopeia that became known as Maffei 1 and 2.

Astronomers think that, if not for its proximity to the galactic plane (about 0.5° away), Maffei 1 would be among the sky's brightest galaxies. Dust has dimmed this E3-class elliptical by an estimated 4.7 magnitudes to magnitude 11.1, although its visible-light surface brightness — spread over 3.4' by 1.7' — is so low that it appears even fainter. In infrared light, however, the galaxy looks much larger. At an estimated distance of more than 9 million light-years, its long axis is about 75,000 light-years across.

You'll find Maffei 1 slightly more than 4° north-northwest of Eta (η) Persei and 3° northeast of the Double Cluster in Perseus (see #54). But don't be fooled by the galaxy's bright apparent magnitude — Maffei 1 is challenging, requiring a large aperture and dark skies. It wasn't until years after its discovery that this galaxy was pulled from obscurity, which is why it isn't on many observing lists. Look for a faint glow superimposed with a sprinkling of faint foreground stars.

Maffei 1 is the brightest member of the nearest group behind the Local Group, along with Maffei 2 and IC 342 — the latter a large, open-face spiral with a low surface brightness in Camelopardalis.

Among the objects in this list, Maffei 1 is noteworthy in two ways: It is one of the most recently discovered targets and is among the most challenging to observe. — A.G.

JOHN CHUMACK

31 M101 →

While the name Pinwheel Galaxy can refer to M33 in Triangulum and other open spirals, it is the most common moniker for M101 (NGC 5457) in Ursa Major. Located near Alkaid (Eta [η] Ursae Majoris) at the end of the Big Dipper's handle, M101 can be a wonder or a disappointment, depending on observing conditions. Under ideal dark skies, you can spot M101 in large binoculars, where it forms the apex of an equilateral triangle with Alkaid and Mizar (Zeta [ζ] Ursae Majoris). The core is relatively easy to observe in small scopes, while the dim spiral arms require excellent transparency in dark skies away from urban light pollution. The arms' asymmetry is readily apparent when they are resolved. With sufficient aperture, you may even see features that correspond to the Milky Way's Scutum Star Cloud and Carina Nebula (see #67).

M101 was discovered by Charles Messier's assistant, Pierre Méchain, in 1781. It's a face-on spiral galaxy whose Sc classification indicates a small central hub and expansive spiral arms. Located some 27 million light-years from us, it's a big one as spiral galaxies go — 70 percent larger than the Milky Way — and contains an estimated 1 trillion stars.

Despite its mass, M101's arms are distorted due to interactions with at least a half-dozen companion galaxies, including NGC 5204, NGC 5474, NGC 5477, NGC 5585, UGC 8837, and UGC 9405. In 1990, Paul Hodge and collaborators published an atlas of 1,264 HII regions in M101. Only the largest are visible in amateur telescopes and three have *New General Catalogue* numbers: NGC 5461, NGC 5462, and NGC 5471.

M101's magnitude of roughly 7.8 means it should be easy to see in small instruments. However, that is not the case. This open-arm spiral has low surface brightness due to its orientation and expansive size: 29' by 27'. Our line of sight is perpendicular to M101's disk, so we observe directly through its galactic plane. If this galaxy's tilt was instead at a high angle — say, 45° — the starlight would be more concentrated. —A.G.

RODNEY POMMIER

32 The Omega Nebula ↑

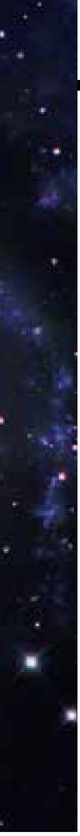
In 1764, Swiss astronomer Philippe Loys de Chéseaux discovered the beautiful Omega Nebula (M17) in Sagittarius. He described it as having "the shape of a ray, or of a comet tail. ... Its sides are exactly parallel and quite well defined, much like its ends."

The object's nickname, however, didn't come until John Herschel jotted down his description of it in 1833. Specifically, Herschel wrote that "its form is that of a Greek Omega with the left base-line turned upwards." Herschel later mentioned that it also reminded him of a horseshoe. Others see it as a swan, a checkmark, and even the number 2 with an extended base.

No matter what you call it, M17 is bright enough that it is easily visible with binoculars. Through a 4-inch telescope, the checkmark or number 2 shape is readily seen. But it will take at least an 8- or 10-inch scope to make out the full bow of the omega or horseshoe. The brighter portions along the nape of the swan's neck and extended body show a richness in textural detail unparalleled in most nebulae. A narrowband light-pollution or oxygen-III (OIII) filter will greatly improve the view of these textures.

The Omega Nebula is a massive HII region marking the tip of an interstellar iceberg: a giant molecular cloud inside one of our galaxy's spiral arms. Waves of star formation have produced a packed star cluster hidden within the swan's neck. Known as NGC 6618, this cluster holds an estimated 10,000 stellar infants, which astronomers believe are no more than about a million years old. Due to opaque cosmic dust, however, the cluster is only readily visible at infrared wavelengths.

Residing along our galaxy's Sagittarius spiral arm near the Omega Nebula is the Eagle Nebula (see #93). At 5,600 light-years away, the Eagle is the closer of the two; Omega is located some 400 light-years farther away. Estimates tell us that the Omega, at 70 light-years across, is roughly twice the size of the Eagle. —P.H.



33 The Southern Pleiades ↓

The Southern Pleiades (IC 2602) in the constellation Carina the Keel is a dazzling open cluster. It lies 550 light-years away and occupies a region 50' in diameter. That's 2.6 times as much area as the Full Moon covers.

IC 2602 contains about 75 stars surrounding blue, magnitude 2.7 Theta (θ) Carinae, so it's sometimes referred to as the Theta Carinae Cluster. More commonly, however, observers call it the Southern Pleiades because its discoverer, French astronomer Nicolas Louis de Lacaille, compared it to the Pleiades (M45; see #8) in the northern constellation Taurus the Bull.

Astronomers originally thought IC 2602 was a young object, on the order of 15 million years old. Recent studies at the Anglo-Australian Observatory, however, have placed its age closer to 45 million years — which is still pretty young for an open cluster.

With a total magnitude of 1.9 (which makes it 52 percent as bright as M45), the Southern Pleiades ranks as the fifth-brightest open cluster in the sky. Most observers agree that, as with the northern Pleiades, IC 2602 looks better through binoculars. That's because telescopes, though they provide increased magnification, have a more limited field of view and spread out the stars too much. If, however, you can use a short-focal-length scope with an eyepiece that gives a 1½° field of view, this collection of stars will knock your socks off.

Through such an instrument, it looks like you're viewing two clusters with a 0.3°-wide gulf between them. The westernmost group includes Theta Carinae and two curving lines of stars that start at Theta. One heads north and the other south.

Some observers think that the eastern half of IC 2602 looks like a tiny Orion, whose stars have different relative brightnesses than those in the winter constellation. — M.B.

PATRICK WINKLER

34 M109 ↑

The third-largest constellation in the sky, Ursa Major, contains seven Messier objects. Five are galaxies. The least observed of these — based on the number of books and articles featuring it — is M109, also known as NGC 3992. Messier's original catalog topped out at 103, but today, astronomers recognize 109 objects.

Discovered in 1781 by Pierre Méchain, M109 is the most distant Messier object, located a whopping 83.5 million light-years away. (The closest is M45, the Pleiades open cluster, at only 445 light-years.) Although difficult to observe visually because of their low surface brightness, the galaxy's arms are complex and somewhat symmetrical. M109 is a barred spiral, but unlike the more classic S-shaped galaxies of this type, its bar ends in short counterclockwise arms that wrap so closely on one another that they form what looks like an encompassing ring. Both large, clockwise (regular) arms split into two, giving the galaxy a modified S shape. As a result, M109 is classified as an SBbc(rs) galaxy, with rs indicating it has both ring and S-shaped structure. Only one supernova, which went off in 1956 and reached magnitude 12.4, has been documented in this galaxy.

For a non-naked-eye object, M109 is easy to locate, only ¾° southeast of Phecda (Gamma [γ] Ursae Majoris). Under low power, the star can interfere with seeing M109 at its best. The galaxy's visual magnitude is 10.6, bright enough to be seen in small scopes. Its dimensions of 7.6' by 4.7' make it larger than many galaxies, but it is one of the smallest Messier galaxies in Ursa Major. (Only M102 [NGC 5866] is smaller.) As galaxies go, it's unimpressive with small instruments. All you will see is the condensed core and the brightest part of the bar. Even larger scopes have trouble with the low-contrast detail unless the night is free of light pollution.

M109 is the brightest member of the M109 Group, which consists of about 33 mostly spiral galaxies spanning 11° in declination and 40' in right ascension. The closest bright member is NGC 3953, a 10th-magnitude SBbc spiral with a tiny bar and multiple arms, which sits roughly 1° southeast of M109. — A.G.

MARCO LORENZI

35 M84 ↓

M84 is a member of a dynamic pairing with M86 (see #36). A round giant elliptical galaxy some 80,000 light-years wide, M84 shines across 55 million light-years of space. It resides in the Virgo Cluster of galaxies, the nearest of the large extragalactic populations. This, of course, was unknown to Charles Messier when he discovered it on March 18, 1781, noting that its "center is pretty bright, surrounded by slight nebulosity." Little has changed in astronomers' descriptions of the object to this day.

Elliptical galaxies are one of three main classes of galaxies defined by American astronomer Edwin Hubble in 1936. They have no discernible structure except for their ellipsoidal shape. Nevertheless, they are among the most abundant type of galaxies in the universe and are usually found near the cores of galaxy clusters.


GREG MORGAN

M84 is one of the more prominent ellipticals near the center of the Virgo Cluster. It has a compact nucleus and two warped dust lanes perpendicular to a radio jet that streams from the core in a north-south direction. This gas disk surrounds a black hole with a mass of about 1.5 billion Suns. M84's outer halo appears smooth, dotted with prominent globular clusters. Its stars appear to be very old, dating back nearly 12 billion years.

To find this 10th-magnitude galaxy, look about 5° northwest of Rho (ρ) Virginis. Through small- to moderate-sized telescopes, the galaxy appears as a 5' glow, slightly out of round with a stellar nucleus surrounded by a tightly packed core. In images, the core's intensity is slightly enhanced by a superimposed 14th-magnitude star.

M84 is visually part of Markarian's Chain, a string of eight galaxies that form a 1.5°-long line that shines like flying paper lanterns at the core of the Virgo Cluster. Armenian astrophysicist Benjamin Markarian discovered this feature in the 1960s, noting that these galaxies share a common motion though space. However, later observations have shown that M84 is not a dynamical member of the chain, as its motion does not jive with the rest. — S.J.O.


GREG MORGAN

36 M86 ↑

M86 is a 9th-magnitude elliptical/lenticular galaxy at the core of the Virgo Cluster, lying only 17' from M84 (see #35). Messier discovered it together with M84, saying the two "nebulae" had the same appearance. On the surface, they do. With its smooth-looking face, M86, like M84, gets gradually fainter the farther you look away from the core. And at a glance, M86 may appear only slightly larger than M84 through a small telescope.

But this is an illusion created by the galaxy's lower surface brightness. M86 is, in fact, twice the apparent diameter of M84 and is slightly more elliptical. M86's 400 billion stars span a whopping 135,000 light-years.

Aside from its sharp nucleus in a diffuse core, M86 is a visual "softy" — a porcelain-pure oval of diffuse light. Studies of M86's core have revealed a slight dimming, which could suggest the core is surrounded by a dust ring or torus, though other studies have contested this.

M86 is tidally interacting with NGC 4438 (about 25' to the east-northeast), and a nearly 400,000-light-year-long Hydrogen-alpha filament clearly connects them. While M86 does not have an apparent outer envelope, it does harbor some 3,800 globular clusters. It doesn't seem to be interacting with its tiny companion NGC 4402, located about 10' north of its core, though its halo has several streamers, suggesting it has consumed some of its other neighbors in the past.

While the majority of the Virgo Cluster is receding from the Milky Way, M86 is moving closer to our Milky Way Galaxy at 940,000 mph (1.5 million km/h). This is a consequence of M86's orbit around the Virgo Cluster: The galaxy is currently on the far side of the cluster relative to us, and moving toward the cluster's center. — S.J.O.

37 M87 →

M87 is yet another Messier elliptical galaxy in the Virgo Cluster, 55 million light-years distant and some 120,000 light-years across. It lies about 3½° northwest of Rho Virginis. But M87 outdoes M84 (see #35) and M86 (see #36) in sheer mass: It has least a trillion stars totaling a mass of 2.7 trillion Suns. That makes it one of largest, most massive, and most luminous galaxies in our local universe.

Charles Messier discovered M87 on March 18, 1781 — the same night he found M84 and M86 — and one can only wonder what went through his mind as he spotted these three cometlike objects in the same area of sky. At magnitude 8.6, M87 is slightly brighter than the other two and in between them in size.

M87 is most likely the visible remains of an extragalactic merger between two galaxies. This combined cosmic powerhouse now features a furious jet of matter blasting out from its nucleus. Heber Curtis at Lick Observatory first noticed this "curious straight ray" in 1918 on photographic plates. The jet is a very strong central radio source and is powered by a 6.5-billion-solar-mass black hole — one of the largest known. In 2017, astronomers used an international network of radio telescopes called the Event Horizon Telescope to zoom in on the heart of M87 and capture the first image of a black hole and its shadow, which was released in April 2019.

The first visual observation of M87's 5,000-light-year-long jet was made by Otto Struve through the 100-inch telescope at Mount Wilson. It was thought to be beyond the grasp of amateur astronomers until the late Barbara Wilson first sighted it through her 20-inch reflector during the 1991 Texas Star Party. Otherwise, the galaxy is quite typical for an elliptical. Namely, it resembles an unresolved globular cluster or the head of a comet just beginning to shine — one with a bright spherical shell that gradually condenses inward. A dimmer elliptical, 11th-magnitude NGC 4478, lies only 10' southwest of M87; it requires modest to high magnifications to see well. — S.J.O.


ADAM BLOCK/NOAO/AURA/NSF

38 The Owl Nebula

STEVEN MYATT

Among the planetary nebulae in the high northern heavens, M97, the Owl Nebula, is the most famous. Pierre Méchain discovered it on Feb. 16, 1781, about 2.5° southeast of Merak (Beta [β] Ursae Majoris), noting it was difficult to see with crosshairs illuminated. Messier agreed, recording, "its light is faint." The difficulty is not so much its brightness (magnitude 9.8), but that its dim light is spread across nearly 3.5' of sky. Nevertheless, today the Owl is one of the most sought-after planetary nebulae in the sky, mainly because it presents observers with a challenge: literally seeing eye-to-eye!

The "owl" moniker comes from a sketch made in 1848 by William Parsons, Earl of Rosse, through his 72-inch Birr Leviathan reflector, which shows the round nebula's curious eye-like hollows. With a star in each socket, these eyes seem to peer out from a face similar to that of a barn owl. Lord Rosse wrote that the stars were "considerably apart in the central region" and surrounded by a "dark penumbra." Small-telescope users can infer the Owl's eyes at moderate magnifications by sweeping their gaze back and forth across M97's softly glowing circular disk, which shines with a pale gray pallor. Switch to high power (350x and greater) to search for the two dim stellar pupils.

Lying some 2,600 light-years distant, this planetary nebula sports a classical circular planetary shape with a complex structure consisting of three concentric shells: a faint outer halo, a circular middle shell, and a roughly elliptical inner shell. These shells were expelled from its dying Sun-like star beginning some 6,000 years ago. First, normal stellar winds created the outer shell after fusion in the parent star's core ceased. Then the star began shedding its mass very quickly in a superwind, which drove even more gas and dust outward to form the middle shell. Finally, an even faster stellar wind compressed the superwind to form the inner shell and a bipolar cavity — a barrel-like component oriented at an angle 45° to the line of sight whose matter-poor tips create the Owl's eyes. If you have trouble perceiving the eyes, try instead for the dim bar of light that separates them. — S.J.O.

39 North America Nebula

NGC 7000 looks as big as a continent — the continent of North America, to be exact. This emission nebula lies near Deneb in the tail of Cygnus. It is 2° by 1⅔° across, or 10 times the area of the Full Moon. William Herschel discovered it, but it was cataloged by his son, John. They both saw the shape as indistinct, combined with abundant stars in the Milky Way. German astronomer Max Wolf photographed the area in 1890 and named it the North America Nebula. NGC 7000 is part of a larger complex — Sharpless 2-117 — that includes the Pelican Nebula (IC 5070) and the swath of dark dust that separates the two, named L935 by Beverly Lynds in 1962.

Edwin Hubble proposed that the hot, luminous star Deneb was responsible for ionizing the North America Nebula's gas, making it glow. However, at a mere 14,840 degrees Fahrenheit (8,230 degrees Celsius), Deneb is not hot enough. It's also too far from the nebula. Instead, the nebula's real energy source — the star J205551.3+435225 — is five times hotter than Deneb. It lies between the North America and Pelican nebulae, embedded within L935. That dark nebula dims the spectral type O3.5 star by 9.6 magnitudes; it would otherwise be one of the brightest stars in Cygnus.

For Northern Hemisphere observers, Cygnus lies in the bright patch of Milky Way visible in the late summer and autumn skies. Within that, the North America Nebula is bright enough that, in theory, it could be seen with the naked eye under perfect skies. With very good conditions, the right binoculars will show it as a large, amorphous glow 3° east of Deneb. In a 4- or 6-inch rich-field telescope with a wide-field eyepiece, the nebula fills the field of view. The Atlantic Coast and Florida are its most distinct features, thanks to their contrast with the adjacent dark nebula. Mexico is less conspicuous and the West Coast blends into the rich Milky Way star field. UHC filters really bring out the nebula, while reducing the glare from the foreground stars. — A.G.

JASON WARE

40 The Jewel Box →

DON GOLDMAN

If you're an amateur astronomer planning to travel south of the equator, one of the best celestial sights you can point your telescope at is the Jewel Box (NGC 4755). This collection of stars ranks as one of the sky's finest open clusters. But it's not because of its size (10' in diameter) or brilliance (magnitude 4.2), nor even the number of stars it contains (more than 100). The reason the Jewel Box enthralls observers is its colorful collection of stars.

Most open clusters contain hot, recently formed stars, which look blue through a telescope to most observers. The Jewel Box, however, contains more than half a dozen stars of various shades of blue, yellow, and orange. Astronomers think NGC 4755, at 14 million years old, is one of the youngest open clusters. It lies some 6,400 light-years from Earth.

French astronomer Nicolas Louis de Lacaille discovered NGC 4755 with a ½-inch refractor in 1751, when he traveled to the Cape of Good Hope in South Africa. But English astronomer Sir John Herschel's eloquent description — "a superb piece of fancy jewellery" — led to other astronomers coining the popular name Jewel Box.

NGC 4755 has yet another name: the Kappa (κ) Crucis Star Cluster. At magnitude 5.9, Kappa Crucis reigns as the second-brightest star in the cluster. The only other cluster member that tops it — by an almost indiscernible 10 percent — is SAO 252069, which glows at magnitude 5.8.

The Jewel Box lies 1° southeast of magnitude 1.3 Mimosa (Beta [β] Crucis). Sharp-eyed observers at a dark site will spot the cluster without optical aid as a glow that looks like an out-of-focus star.

Most observers viewing NGC 4755 through 4- to 8-inch telescopes with an eyepiece that provides a wide field of view (try a magnification around 50x) see the famous A asterism, which is formed by the stars closest to the center. Take in the whole cluster, and you'll see 10 or more colorful stars, another 20 white ones, and a faint backdrop of more than 100 other cluster members. — M.B.

DOUGLAS J. STRUBLE

41 M106 ↑

The challenges of observing spiral structure in galaxies are many. The two most important considerations are the brightness of the arms and the gaps or distance between them. High-contrast arms are easier to observe in detail with smaller telescopes. And sometimes a galaxy with fewer arms — such as a barred spiral, which often has two — presents clearer arm structure than a galaxy with many arms.

One such barred spiral is M106, located roughly midway between Beta (β) Canum Venticorum and Gamma (γ) Ursae Majoris. Also designated NGC 4258, this galaxy is inclined 64° from face-on. At about 9th magnitude, the galaxy may be seen in small instruments. Its spiral structure is visible in moderate telescopes and becomes more conspicuous with increasing aperture. Beyond the bar structure is an extended disk with a lower surface brightness.

M106 is one of five Messier objects in the small, galaxy-rich constellation of Canes Venatici. M3 is a globular cluster, while the others — M51, M63, and M94 — are spiral galaxies, each with unique characteristics. M106 is an SBbc spiral with a generous size of 18.7' by 7.2', corresponding to 135,000 light-years across at its distance of 24 million light-years. It is one-third larger than the estimated size of our Milky Way.

When you observe this galaxy, look for the bright, starlike nucleus. With small telescopes, you will more easily see the core than its other morphological features. Here, you are looking at an explosive nucleus powered by a black hole with some 30 million solar masses.

In the early 1940s, Carl Seyfert studied galaxies with spectroscopy. M106 is classified as a type 2 Seyfert galaxy, due to the narrow emission lines in its spectrum. Later research of such so-called active nuclei found they are similar to quasars, but the galaxies surrounding them are more noticeable because the central black hole's energy emission is lower. This galaxy also contains water vapor masers — regions of excited atoms that emit coherent light in microwaves instead of visible light like a laser. Watching the motions of these masers allowed astronomers to directly determine the distance to another galaxy, independent of other indicators, for the first time.

While you're in the neighborhood, check out NGC 4248, a magnitude 12.5 dusty edge-on spiral and likely companion to M106 and NGC 4217. The latter is a more distant edge-on spiral, with a dust lane and a magnitude of 12.4. — A.G.

GEORGE CHATZIFRANTZIS

42 The Dumbbell Nebula ↑

While most planetary nebulae are small and beautiful, there is no doubt that the Dumbbell Nebula (M27) is something special. Found by Charles Messier in July 1764, M27 was the first planetary nebula ever discovered. He described it as a "nebula without star … oval in shape."

Decades later, John Herschel remarked it resembled "a nebula shaped like a dumbbell," a nickname that stuck. He also subsequently coined a second nickname when he wrote it is "shaped something like an hourglass." Others have tagged it the Apple Core Nebula and the Bow Tie Nebula.

Located in the summer constellation Vulpecula the Fox, the Dumbbell is one of the brightest planetary nebulae in the sky. Binoculars and finder scopes reveal it as a rectangular patch of light with a hint of a tapered waist, floating in a star-studded field 3° due north of Gamma (γ) Sagittae.

With a telescope, use low power to find it, then switch to at least 100x for the best view. Inserting a narrowband or OIII filter will help accentuate its structural details. The nebula's brightness is clearly asymmetrical, with the southern half of the hourglass outshining its northern counterpart. Fainter perpendicular extensions, which some call ears, protrude away from the center. These are best appreciated in larger scopes at low power with a contrast-enhancing nebula filter. Centered in all of this hides a white dwarf, the remnant of the star that gave birth to the nebula some 9,800 years ago. Shining at 13th magnitude, the white dwarf usually requires at least a 10-inch scope to ferret out.

Each planetary nebula is unique because its appearance depends so much on the angle at which it presents itself to us. Viewed on-axis, many show nearly circular rings or disks. But viewed from the side, planetaries can take on long, cylindrical profiles. In the case of the Dumbbell, it is a prolate spheroid — picture a football with more rounded ends. The bright hourglass shape spans the spheroid's short (minor) axis. The fainter ears align with its long (major) axis. — P.H.

43 NGC 891 ↓

Edge-on galaxies are relatively common among the thousands visible throughout the sky. Many even sport dust lanes splitting their galactic plane, adding visual intrigue. One such galaxy is NGC 891 in Andromeda.

Finding NGC 891 isn't difficult. Start with Almach (Gamma [γ] Andromedae) and move your telescope 3½° east. The Silver Sliver Galaxy, as NGC 891 is also called, is in a rich star field, which adds to its visual aesthetic.

At magnitude 10.8, this galaxy is visible with a telescope as small as 3 inches under excellent skies — but only just. Six-inch or larger optics are better, and in a 12-inch or larger scope with dark skies, the spiral's disk starts gaining positive superlatives beyond, "Yep, there it is." The thickness of this galaxy's dark nebulae reduces its visual contrast with the background sky, making it harder to see than an edge-on galaxy without a dust belt. Using averted vision is a definite advantage here, so try wiggling the telescope or scanning the field while keeping the galaxy in the corner of your eye.

NGC 891 is classified as Sb, like the Andromeda Galaxy (M31; see #100). Since it's edge-on, astronomers cannot determine its arm structure. Is it more like M31 or M81? We will never know. The Hubble Space Telescope shows that NGC 891's dust and gas are distributed into numerous filaments, like fingers reaching out above and below the galaxy's equator. Researchers hypothesize that these filaments were created by a combination of supernovae and the formation of energetic massive stars. NGC 891's bilateral symmetry shows that it hasn't collided with another large galaxy in the last billion years or so.

Other tidbits of trivia: Hollywood found the galaxy's image so compelling that it appears in the credits sequence of *The Outer Limits* — among other objects described in *Astronomy*'s June 2019 story "*The Outer Limits* universe." The soundtrack for John Carpenter's 1974 film *Dark Star* included a track called "When Twilight Falls on NGC 891." That same year, Edgar Froese released an album that included the song "NGC 891." — A.G.

DAN CROWSON

44 M37 ↓

While Charles Messier found M37 (along with M36) on Sept. 2, 1764, he wasn't the first to discover this cluster. Giovanni Battista Hodierna (sometimes spelled Odierna) had noted it — along with M36 and M38 — 110 years earlier in a book on cometary and non-cometary celestial objects.

The premier open cluster in Auriga, M37 is the richest of the Charioteer's three Messier clusters, with about 150 stars brighter than magnitude 12.5 packed in a region 24' across. Its integrated magnitude is listed between 5.6 and 6.2 — bright enough to see with the naked eye. Look for it outside of the pentagonal outline of the constellation. If you draw a line between Theta (θ) Aurigae and Beta (β) Tauri, M37 lies slightly northeast of its midpoint.

Auriga lies on the galactic plane in the opposite, or antipodal, direction of our galaxy's nucleus, located in Sagittarius. Sitting at the inner edge of the Milky Way's Perseus Arm, M37 is 4,500 light-years away. By comparison, the intrinsically more luminous Owl Cluster (NGC 457; see #55) is only slightly fainter in apparent brightness, but some 3,400 light-years more distant, in the outer Perseus Arm.

M37 is visible as a nebulous patch in binoculars and small scopes. In a 3-inch scope, the brightest stars are apparent; with increasing aperture, more stars become visible. In a 6-inch telescope at low power, you may see some 25 stars. With higher magnification in the same scope, the number increases to more than 40. The fainter members crowd the field of view in large instruments, adding to the already rich foreground stars.

At an estimated 300 million to 500 million years old, one might consider this cluster on the older side of middle age. Compare that to its less mature neighbors: M38 is 220 million years old, while M36 is an even younger 25 million years old. M37 has orbited the Milky Way twice in its lifetime, yet it still maintains a dense pack of members. About a dozen of its stars have evolved into red giants, so look for some color sprinkled in the mix. — A.G.

DAN CROWSON

45 NGC 1365 →

Most observers would admit that, out of all galaxies, barred spirals make the best targets for amateur telescopes. That said, it's a pity the best example of a barred spiral — NGC 1365 — languishes in the nearly invisible constellation Fornax the Furnace.

As galaxies go, NGC 1365 is bright: magnitude 9.4. It's also not tiny, measuring 8.9' by 6.5'. It lies some 60 million light-years away and is part of the Fornax Cluster of galaxies, the second-richest nearby grouping of such objects (topped by only the Virgo Cluster). The Fornax Cluster boasts more than 2,600 members.

Astronomers using the Hubble Space Telescope revealed that NGC 1365 feeds material into its central region, igniting massive bursts of star formation and growing its central bulge. The material also feeds a 2-million-solar-mass supermassive black hole in the galaxy's core.

Although it's bright, NGC 1365 isn't that easy to find if your telescope doesn't have a go-to drive. To locate it, first find a triangle of three faint stars that lie 7½° south-southeast of magnitude 3.9 Alpha (α) Fornacis: magnitude 6.4 Chi^1 (χ^1), magnitude 5.7 Chi^2 (χ^2), and magnitude 6.5 Chi^3 (χ^3) Fornacis. From Chi^2, which is the brightest, move 1.3° east-southeast.

A 4-inch scope at a dark location will reveal NGC 1365's bar and brighter central region. With an 8-inch or larger instrument, you can crank up the power to also see the arms. The northern one, which starts at the west end of the bar, is brighter. The other is a bit blotchy because it contains huge star-forming regions. — M.B.


MARK JOHNSTON

46 California Nebula ←

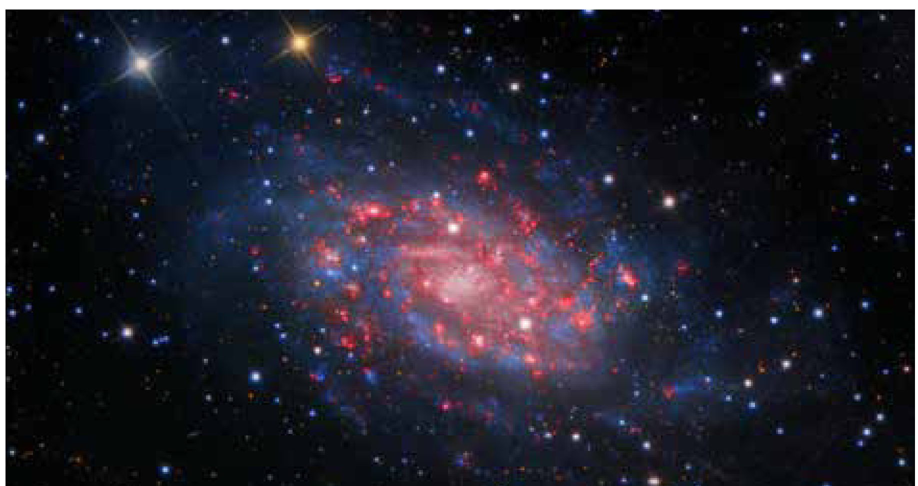
Today's brightly lit cities aren't usually the places where new deep-sky objects are discovered, but in the 19th century, gas streetlights didn't produce much light pollution. In November 1885, Vanderbilt University astronomer Edward Emerson Barnard visually discovered the California Nebula from Nashville, Tennessee, with a 6-inch refractor. One of the pioneers of astrophotography, Barnard is perhaps better known for his catalog of dark nebulae.

Designated NGC 1499, the California Nebula is an emission nebula stretching 2½° long and ½° wide. Its apparent magnitude of 6 suggests it can be seen in small optics. But this nebula's expansive and diffuse nature gives it a low surface brightness, making it difficult or impossible to see except under the darkest skies (i.e., where magnitude 6.5 stars are visible with the naked eye).

As you might expect, the California Nebula is relatively close to Earth — estimates put it between 1,000 and 1,500 light-years away. That places the length of this hydrogen cloud somewhere around 100 light-years from end to end. For comparison, the famous Orion Nebula (M42; see #19) is about 1,600 light-years distant but only 24 light-years in diameter.

HII regions such as NGC 1499 are always illuminated by nearby hot, young stars. The California's source of ionizing energy is Xi (ξ) Persei, which sits on the nebula's Nevada side (what would be the state's eastern border). Also called Menkib, this 4th-magnitude star is classified as O7.5 and has a surface temperature of 62,540 degrees Fahrenheit (34,730 degrees Celsius) — one of the hottest naked-eye stars. Its distance is 1,200 light-years.

To improve your odds of seeing NGC 1499, you will need the right skies and equipment. As mentioned, perfect skies are a necessity; a wide field of view is important to pick up the entire nebula, though a smaller field can bring out one edge. A filter that enhances Hydrogen-alpha (Hα) wavelengths and suppresses airglow will best show off this gas cloud. — A.G.


TONY HALLAS


BERNARD MILLER

47 NGC 2403 ↑

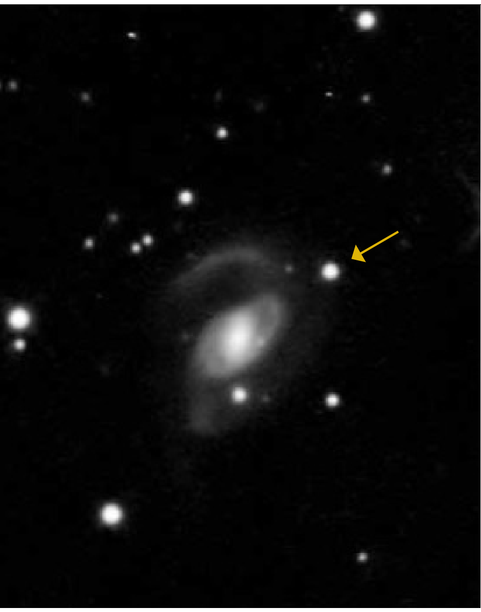
The 18th-largest constellation, Camelopardalis, depicts a giraffe that stretches from the northern border of Perseus up to near Polaris. Its brightest star, designated Beta (β), is 4th magnitude. Camelopardalis is rich in galaxies, and the brightest is NGC 2403 at magnitude 8.9 — bright enough to see in large binoculars under dark skies.

Some 10 million light-years away, this Scd spiral lies in the outer regions of the M81 Group, the closest association of galaxies to the Local Group. It appears similar enough to M33 in Triangulum (see #61) that Allan Sandage wrote a comparison of the two galaxies in his 1961 book *The Hubble Atlas of Galaxies*. NGC 2403 is 50,000 light-years in diameter and inclined to our line of sight by 60° — that's 10,000 light-years smaller and 5° more inclined than M33.

NGC 2403 contains NGC 2404, a massive HII region roughly 940 light-years across. For comparison, the Large Magellanic Cloud's Tarantula Nebula (see #22) is 1,000 light-years across. These are all young star-making machines.

While NGC 2404 may require a large telescope to see well, more modest instruments can reveal NGC 2403's spiral structure. Discovered by William Herschel in 1788, this galaxy isn't difficult in a 4-inch and shows its generous 17.8'-by-11' dimensions in an 8-inch. A 13-inch scope can tease out some of the spiral structure, and larger apertures show even more detail, including mottling from stellar associations and HII regions. There are faint foreground stars superimposed on this galaxy that might be mistaken for supernovae.

NGC 2403 is in an area lacking bright guide stars. If you want to star hop to find it, the best way is to find Omicron (ο) Ursae Majoris. Center on that star, then locate 23 Ursae Majoris. You'll find NGC 2403 at the same distance and angle from that star but in the opposite direction, near 51 Camelopardalis. — A.G.



ANTHONY AYIOMAMITIS

48 NGC 4319 and Markarian 205

An observer's current technology can limit the ability to answer scientific questions. Film replaced visual observing and CCD chips have now replaced film. And the Hubble Space Telescope and other modern observatories have allowed discoveries far surpassing those achievable with the once all-important Palomar 200-inch telescope.

Halton C. Arp's research into peculiar galaxies highlights this march of science. In the mid-20th century, he observed with Palomar's scope that in many cases, two galaxies appeared close to one another on the sky but had discordant redshifts. Arp hypothesized that these conflicting redshifts arose because, although the galaxies truly were close, one of the two was made from material being ejected by the other.

NGC 4319 and Markarian 205 were one of Arp's most prominent examples. Though Arp reported the two galaxies were connected by a "luminous bridge," redshifts put NGC 4319 at 80 million light-years away and Markarian 205 at 1 billion — 14 times more distant! Today, Hubble shows Arp's purported bridge is actually part of a larger envelope surrounding the foreground galaxy.

NGC 4319 is the brighter member of Arp's duo at magnitude 12.8. It is 3' by 2' across and classified as an SBab barred spiral with a large central hub. The arms at the end of the bar include counter-arms, giving it a ring-shaped appearance. Markarian 205 is considered one of the closest quasars. At magnitude 14.5, it is visible with a 10- to 12-inch scope under skies free of light pollution. This object appears starlike, as the galaxy in which the bright quasar is embedded only became visible with Hubble. When you look at Markarian 205, the photons your eyes are receiving were emitted at a time when simple multicellular plant life began appearing in terrestrial sedimentary rocks during the late Precambrian.

Faint galaxies are always a challenge to find using the star-hop method. This duo is located one-third of the way between Kappa (κ) Draconis and Polaris, forming the apex of a large right triangle with Kappa and Lambda (λ) Draconis. There's also a 5th-magnitude star located about 0.2° southeast of this galactic pair. — A.G.

49 47 Tucanae

Johann Elbert Bode logged this particular object 47th (in order of right ascension) in the Toucan in his 1801 catalog of stars, although he didn't observe it himself. He instead picked it up from Nicolas Louis de Lacaille's catalog. At magnitude 4.1, 47 Tucanae is visible to the naked eye. Considered second only to Omega Centauri in richness and brightness, this globular cluster is a true gem of the far southern sky. It is also designated NGC 104.

As amazing as this globular appears, it is outshone by its celestial neighbor, the Small Magellanic Cloud (see #63). The dwarf galaxy lies some 15 times more distant than 47 Tucanae, which is roughly 13,000 light-years away. With a wide-field telescope, it is easy to get both in the same low-power field — a truly awesome sight!

About the same diameter in the sky as the Full Moon (30.9'), this cluster is ideal for a small telescope with low and moderate magnification. With larger optics, the colors of the brightest stars become conspicuous. This is true for most bright globular clusters.

Observers who have seen a handful of globulars are aware that while these are all ancient spherical aggregates of stars, they don't all look the same. Some have sharply concentrated cores, some are gradually concentrated, and some are more evenly illuminated across their width. Astronomers suspect some clusters with dense cores have central black holes, just like most galaxies harbor central supermassive black holes.

In 1999, astronomers targeted 47 Tucanae's dense core with the Hubble Space Telescope in a survey to monitor stars, seeking a slight dip in brightness as planets pass in front of them. They didn't find any here, suggesting planets must be rarer in globular clusters than in open clusters. Researchers believe this is due to the composition of a globular's stars — mostly hydrogen, and lacking in the heavier elements necessary to birth planets.

But 47 Tucanae does have a plethora of other interesting targets: It contains 27 fast-rotating pulsars, the spinning remnants of dead stars. Only Terzan 5 in Sagittarius has more, with 39. — A.G.

KFIR SIMON

CHRIS SCHUR

50 The Small Sagittarius Star Cloud ↑

Charles Messier first noted the Small Sagittarius Star Cloud (M24) on June 20, 1764. He subsequently recalled it as a "large nebulosity in which there are several stars of different magnitudes: the light which is diffused over this cluster is divided into several parts." Although it could not be mistaken for a comet, which was the basis for his catalog, he still added it in as M24.

Later observers went on to misidentify M24 as NGC 6603, which is a separate, small, tightly packed open cluster. The confusion wasn't laid to rest until the 1960s, when British astronomer Kenneth Glyn Jones suggested that M24 was actually the larger region known as the Small Sagittarius Star Cloud, which encompassed NGC 6603.

The name "star cloud" is misleading, though. We are not looking at a distinct deep-sky object, such as a star cluster or a nebula. Instead, we are peering through an open window into the inner depths of the Milky Way. The plane of our galaxy is littered with cosmic dust, which is so opaque in some spots that we have no idea what's going on behind it. But in this 1.5° by 0.5° rectangular frame, the dust curtains have been pulled aside, revealing stars more than halfway to the galactic core.

Only appearing as a bright patch of the Milky Way to the naked eye, the Small Sagittarius Star Cloud blossoms through binoculars into countless stars. But what about NGC 6603? This packed but faint open cluster resides in the richest part of the cloud, northeast of its center. Don't expect to see many of this cluster's individual stars, though, unless you observe it through at least a 10-inch scope.

A view of the star cloud does not come without a few intervening dust clouds, either. A pair of dark nebulae, Barnard 92 and Barnard 93, create a silhouette along its northern edge. Barnard 92 is a rectangular ink blot oriented north-south and measuring about 14' by 8'. To its east, Barnard 93 is a smaller 8' by 3', as well as less defined. – P.H.

51 The Little Dumbbell Nebula ↓

While Perseus is best noted for its wealth of clusters, including the famous Double Cluster, it also harbors the exotic and diminutive beauty M76 — one of only four planetary nebulae in Charles Messier's catalog. Commonly known as the Little Dumbbell Nebula, this expanding shell of gas from a dying Sun-like star resembles Vulpecula's Dumbbell Nebula (M27; see #42) in shape, but not in brightness or size. 10th-magnitude M76 is three magnitudes fainter and three times smaller than M27 — though it is nearly twice as far away.

Messier's contemporary Pierre Méchain discovered the Little Dumbbell Nebula on Sept. 5, 1780, communicating to Messier that it is "small and faint" without any stars. To this day, the nebula still causes visual observers to marvel at its subtleties.

DAN CROWSON

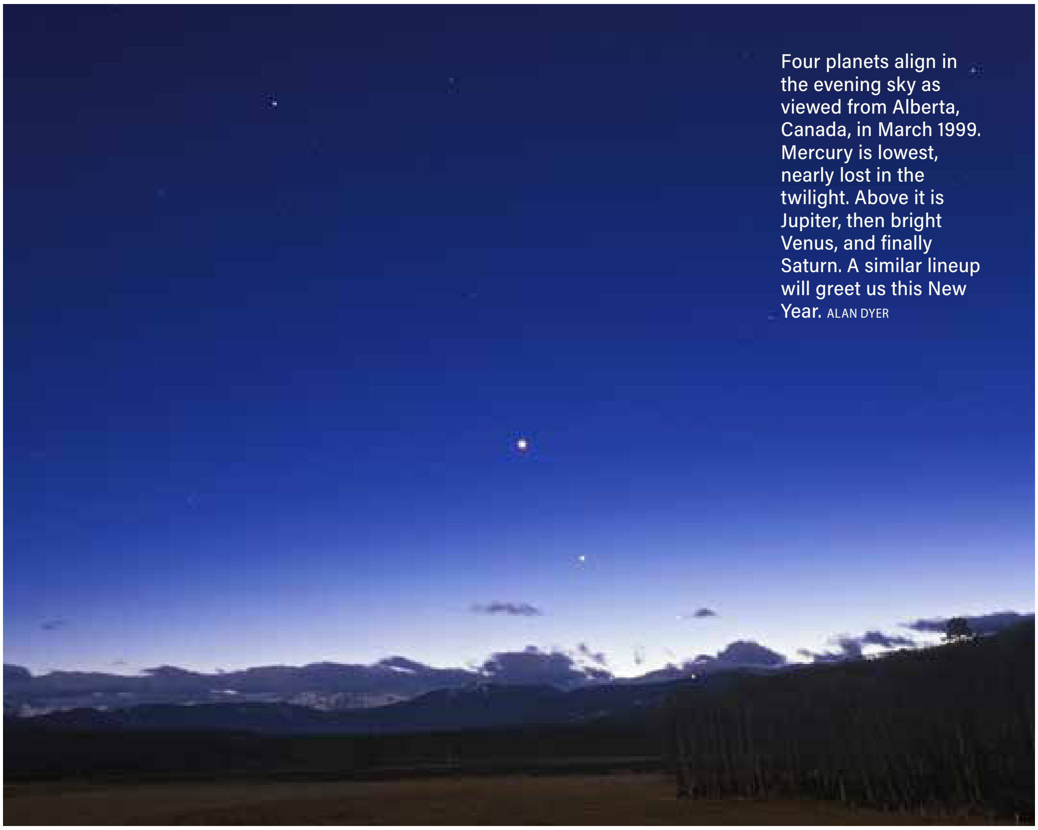
In 1787, William Herschel found that M76 consists of two unresolved nebulae in contact, which became known as NGC 650 (the south component) and NGC 651 (the northern component). In 1891, Isaac Roberts suggested that the object's peculiar rectangular nature is due to observers seeing a ring edgewise. He was right: M76 is a bipolar planetary nebula, with a dusty, doughnut-shaped ring (or torus) that we see nearly edge on. The butterfly wings extending from the torus are expanding bubbles of gas ejected from the central star's polar regions.

M76 lies less than 1° north-northwest of yellowish Phi (ϕ) Persei. Its oft-quoted magnitude of 12.2 is much too faint. Use moderate magnification to seek it out and expect a 10th-magnitude, small, diffuse glow (oriented northwest-southeast) that swells to about 3' with averted vision. Small to moderate-sized telescopes will show it as a uniform rectangle of light separated by a narrow lane of darkness. Careful scrutiny at high power will reveal its hollow butterfly wings. The central star is a challenge, shining around magnitude 16.0. – S.J.O.

Visible to the naked eye
Visible with binoculars
Visible with a telescope

THE SOLAR SYSTEM'S CHANGING LANDSCAPE AS IT APPEARS IN EARTH'S SKY.

BY MARTIN RATCLIFFE AND ALISTER LING



Four planets align in the evening sky as viewed from Alberta, Canada, in March 1999. Mercury is lowest, nearly lost in the twilight. Above it is Jupiter, then bright Venus, and finally Saturn. A similar lineup will greet us this New Year. ALAN DYER

JANUARY 2022

Four planets line up

The new year opens with a spectacular array of planets lined up in the western sky soon after sunset. Mercury, Venus, Jupiter, and Saturn offer nightly fascination. A crescent Moon skips along this line of planets over a few nights early in the month. The inner pair of planets, Mercury and Venus, swaps places in the first week of January. Mercury remains in view through mid-month, while Jupiter and Saturn are visible all month. Uranus and Neptune can be spotted with binoculars, riding high in the southern sky after sunset.

Only Mars is missing from the nightly lineup — it's over in the morning sky, transiting the rich star clouds of the Milky Way.

Four major planets crowd the evening twilight sky in early January, strung like jewels on a necklace along the line of the ecliptic. Catch them Jan. 1, because **Venus** will dip out of view after the first few days of the month. It's heading to a Jan. 8 inferior conjunction. On Jan. 1, Venus sets about 1 hour after the Sun. Look for it 5° high in the southwest 30 minutes after sunset, shining at magnitude –4.2. Nearby, just 8° to the upper left, is Mercury, glowing a fainter magnitude –0.7.

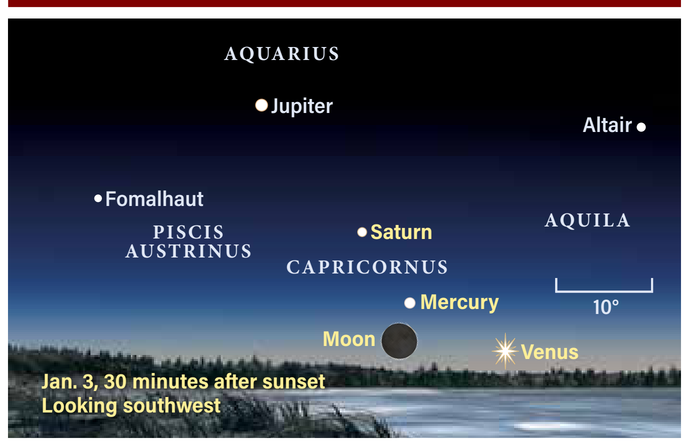
The pair of inner planets is joined by a 1-day-old, very slender (2 percent lit) crescent Moon Jan. 3, just 11.5° left of Venus. Look 12° above our satellite for the ringed planet Saturn (magnitude 0.7) in Capricornus. Higher still, in Aquarius, lies Jupiter, shining at magnitude –2.1. The four major planets span a total of nearly 40°.

Venus drops out of view soon after — how long can you keep track of it in the evening sky? It will reappear in the morning sky around mid-month, rising in the east about an hour before the Sun and shining at magnitude –4.3.

Venus' visibility improves in a darker sky throughout the rest of the month, and it stands 12° high an hour before sunrise on Jan. 31. Through a telescope, Venus changes from a 1'-wide slender crescent that is 1 percent lit on Jan. 15 to a 50"-wide, 15-percent-lit disk on Jan. 31.

Meanwhile, **Mercury** is rising higher each evening, improving its visibility. It climbs toward Saturn and

String of planets



Venus, Mercury, Saturn, and Jupiter add sparkle to the New Year, while a thin crescent Moon joins in, too. ALL ILLUSTRATIONS: *ASTRONOMY*: ROEN KELLY

OBSERVING HIGHLIGHT

MERCURY and **SATURN** mingle close together the evenings of Jan. 12 and 13, when the two sit 3.4° apart.

reaches greatest elongation east (19° from the Sun) Jan. 7, then shining at magnitude –0.5.

Saturn and Mercury appear closest on the evenings of Jan. 12 and 13, separated by 3.4°. Mercury has dipped in brightness to magnitude 0.4 by the 14th, and matches Saturn's brilliance the next evening. The smaller planet fades further as it begins a brisk inward path to its Jan. 23 inferior conjunction. By Jan. 17, it has dimmed to magnitude 1.7 and become much harder to spot in bright twilight. Mercury sets within an hour of sunset.

Saturn falls in altitude each evening as well. On Jan. 4, catch the Moon and Saturn side by side, separated by about 5°. Saturn becomes lost in the solar glow a few days after Mercury and is no longer easily observable. It's only 5° high 30 minutes after sunset on Jan. 20 and, at magnitude 0.7, it's easily lost in twilight.

Jupiter maintains its visibility throughout the month. It's a fine object in late twilight in the first week of January and is the brightest of the evening planets after Venus leaves the scene. On Jan. 1, Jupiter stands roughly 30° high in the southwest an hour after sunset. On Jan. 5, Jupiter is 5° north of the crescent Moon, now just over 3 days old.

Jupiter's disk spans 35" and easily shows off its dusky orange

— Continued on page 38

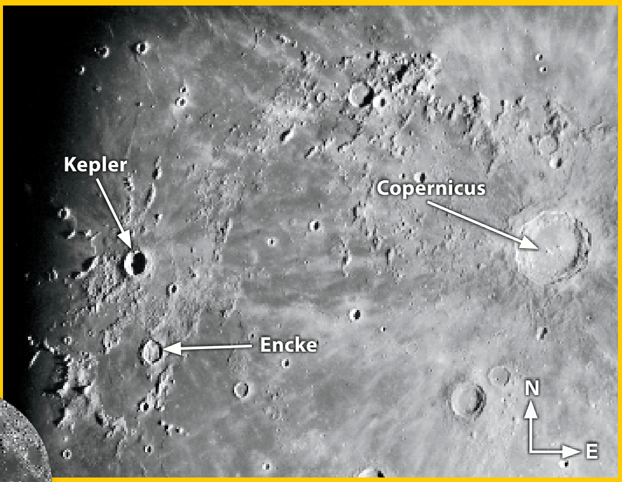
RISING MOON | Ports in a storm

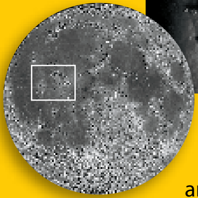
THERE'S NO HIDING the crater Kepler! The youthful impact scar stands out on the Moon's equator, a veritable island in Oceanus Procellarum, the large basin on the eastern flank of our satellite. Kepler is a smaller version of the prominent Copernicus, which lies closer to the Moon's center.

Kepler is a round, sharply defined deep bowl. On the 13th, the low Sun angle highlights the rough skirt of debris that spread out during the impact event that created it. A bit to the south lies Encke, similar in size to Kepler, but its older, bombarded rims are softer and, more importantly, it is filled with Kepler's rubble.

Return in the next couple of evenings to see how a higher Sun angle transforms the roughness and shadows into a bright apron with rays. The lava of Procellarum is thinner here, which permitted the impact to gouge out lighter-hued rock from below. To the south, Encke has all but disappeared. Typically, the older the crater, the less it is visible under a high Sun.

Kepler and Encke

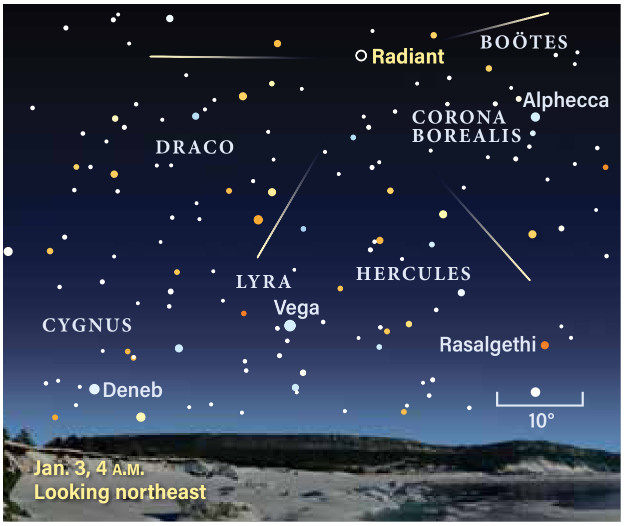




The impact craters Copernicus, Kepler, and Encke are easy to find on Luna's face. *CONSOLIDATED LUNAR ATLAS/UA/LPL. INSET: NASA/GSFC/ASU*

METEOR WATCH | A fine New Year's show

Quadrantid meteor shower



The Quadrantids' radiant is highest before dawn in January. It lies in the now-defunct constellation Quadrans Muralis.

THE QUADRANTIDS, which originate in what is now the northern region of Boötes, are active between Dec. 28 and Jan. 12. The narrow peak of activity (six hours, according to the International Meteor Organization) occurs Jan. 3. With the Moon near New, if the weather cooperates, the chances are good for a fine view. The predawn hours are always the best time to view meteor showers, and the Quadrantids are no exception. The radiant rises late in the evening and by 4 A.M. local time, it's about 40° high. Expect about 25 to 30 meteors per hour if the peak occurs during the dark window of your observing site, corresponding to a zenithal hourly rate of 100 to 120. Look also for the occasional fireball known to occur with this shower.

The Quadrantids' parent object, 2003 EH_1, was discovered in 2003 by Brian Skiff at Lowell Observatory. The former comet nucleus now carries a typical asteroid designation and its orbital parameters closely match those of Quadrantid meteors.

QUADRANTID METEORS

Active dates: Dec. 28–Jan. 12
Peak: Jan. 3
Moon at peak: Waxing crescent
Maximum rate at peak: 120 meteors/hour

STAR DOME

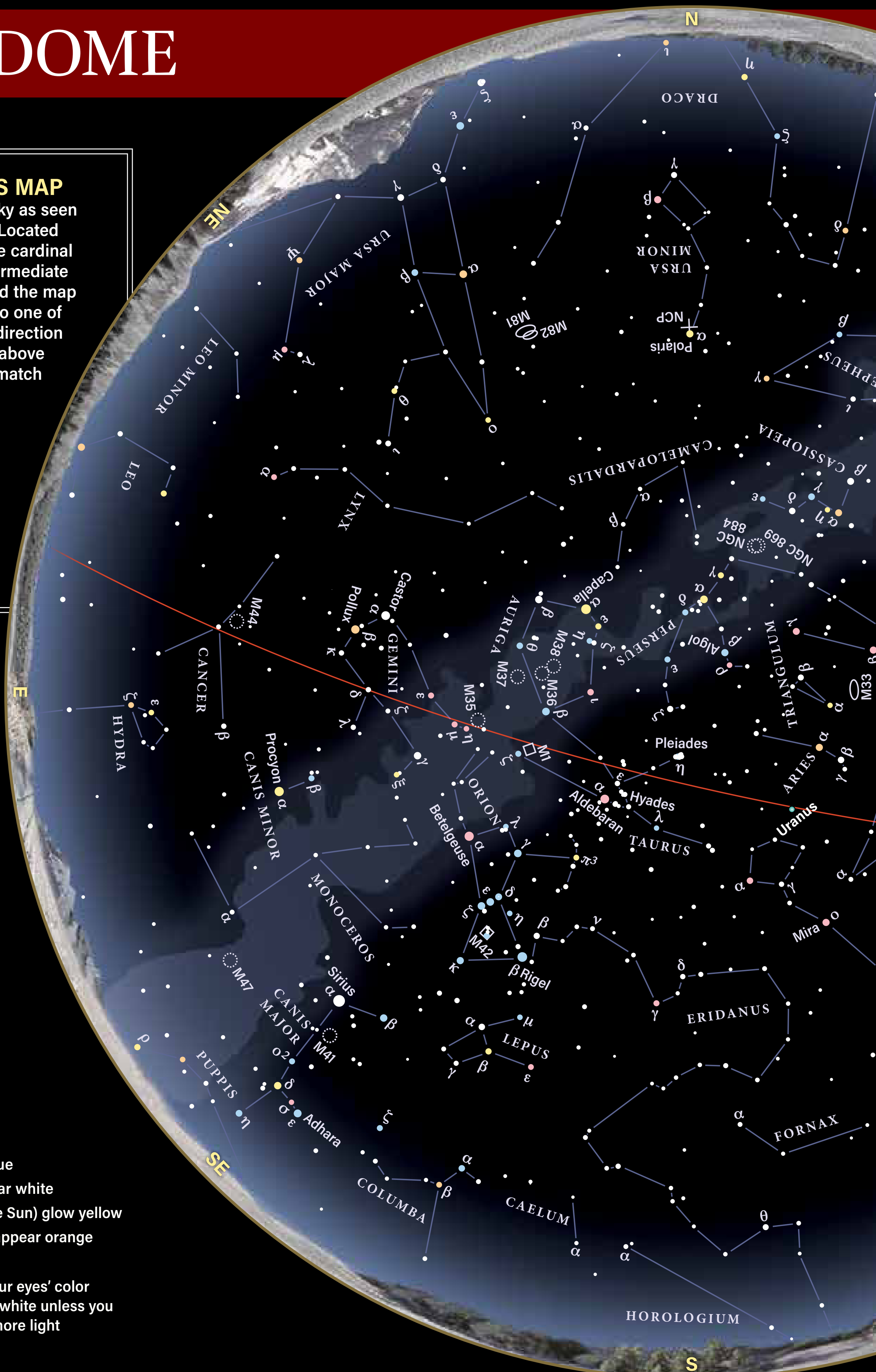
HOW TO USE THIS MAP

This map portrays the sky as seen near 35° north latitude. Located inside the border are the cardinal directions and their intermediate points. To find stars, hold the map overhead and orient it so one of the labels matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows how the sky looks at:

9 P.M. January 1
8 P.M. January 15
7 P.M. January 31

Planets are shown at midmonth



MAP SYMBOLS

- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

STAR MAGNITUDES

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

STAR COLORS

A star's color depends on its surface temperature.

- The hottest stars shine blue
- Slightly cooler stars appear white
- Intermediate stars (like the Sun) glow yellow
- Lower-temperature stars appear orange
- The coolest stars glow red
- Fainter stars can't excite our eyes' color receptors, so they appear white unless you use optical aid to gather more light

BEGINNERS: WATCH A VIDEO ABOUT HOW TO READ A STAR CHART AT **www.Astronomy.com/starchart.**

JANUARY 2022

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	**Note: Moon phases in the calendar vary in size due to the distance from Earth and are shown at 0h Universal Time.**				

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

CALENDAR OF EVENTS

1 The Moon is at perigee (222,471 miles from Earth), 5:55 P.M. EST

2 New Moon occurs at 1:33 P.M. EST

3 Quadrantid meteor shower peaks

The Moon passes 3° south of Mercury, 8 P.M. EST

4 Earth is at perihelion (91.4 million miles from the Sun), 2 A.M. EST

The Moon passes 4° south of Saturn, noon EST

5 The Moon passes 4° south of Jupiter, 7 P.M. EST

7 The Moon passes 4° south of Neptune, 5 A.M. EST

Mercury is at greatest eastern elongation (19°), 6 A.M. EST

8 Venus is in inferior conjunction, 8 P.M. EST

9 First Quarter Moon occurs at 1:11 P.M. EST

11 The Moon passes 1.5° south of Uranus, 6 A.M. EST

Asteroid Juno is in conjunction with the Sun, 5 P.M. EST

12 The Moon passes 1.2° north of dwarf planet Ceres, 7 P.M. EST

13 Asteroid Iris is at opposition, 4 P.M. EST

Mercury is stationary, 8 P.M. EST

14 The Moon is at apogee (252,155 miles from Earth), 4:26 A.M. EST

16 Pluto is in conjunction with the Sun, 10 A.M. EST

Dwarf planet Ceres is stationary, 5 P.M. EST

17 Full Moon occurs at 6:48 P.M. EST

18 Uranus is stationary, 3 P.M. EST

23 Mercury is in inferior conjunction, 5 A.M. EST

25 Last Quarter Moon occurs at 8:41 A.M. EST

29 Venus is stationary, 3 A.M. EST

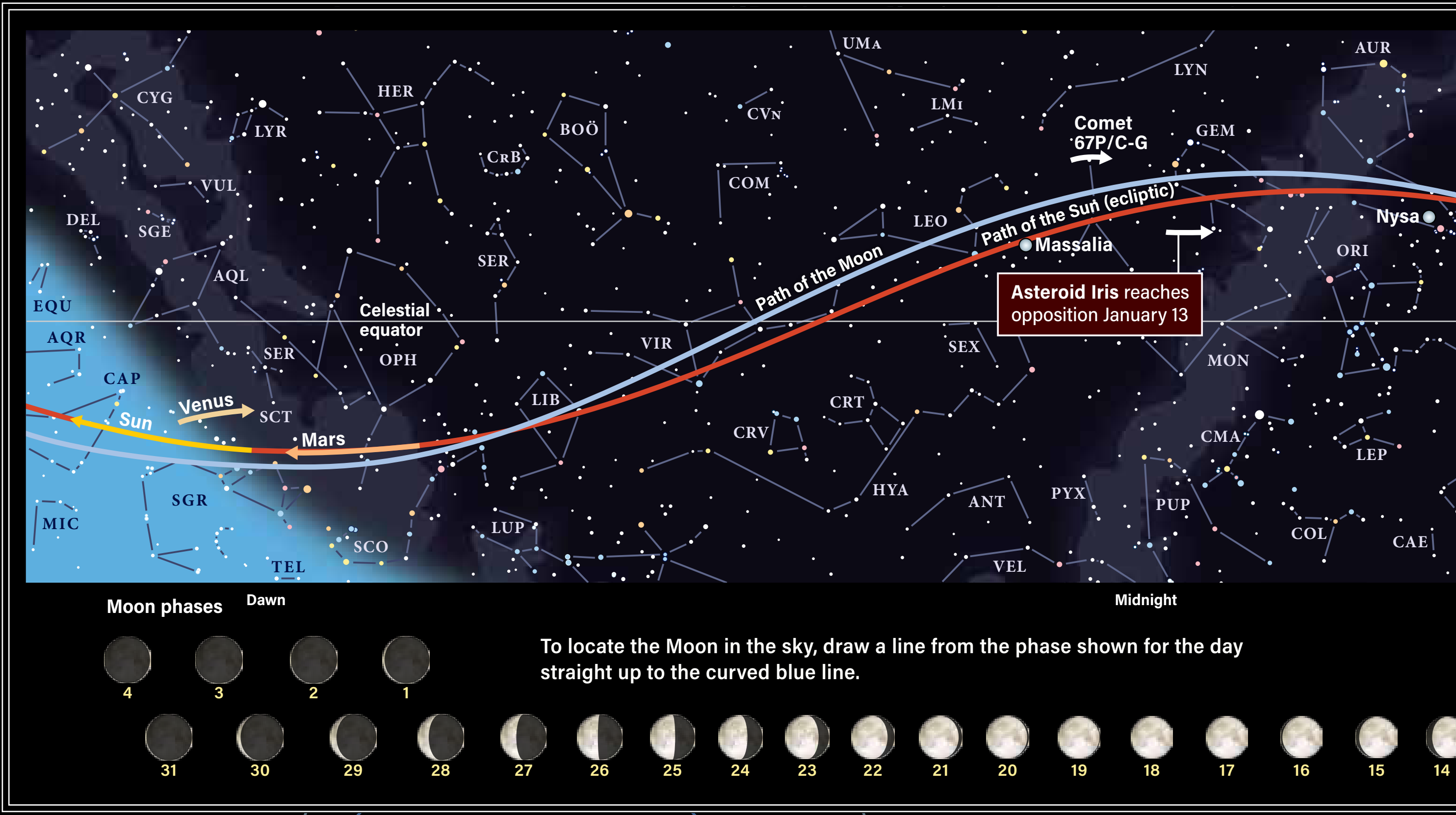
The Moon passes 2° south of Mars, 10 A.M. EST

The Moon passes 10° south of Venus, 9 P.M. EST

30 The Moon is at perigee (225,093 miles from Earth), 2:11 A.M. EST

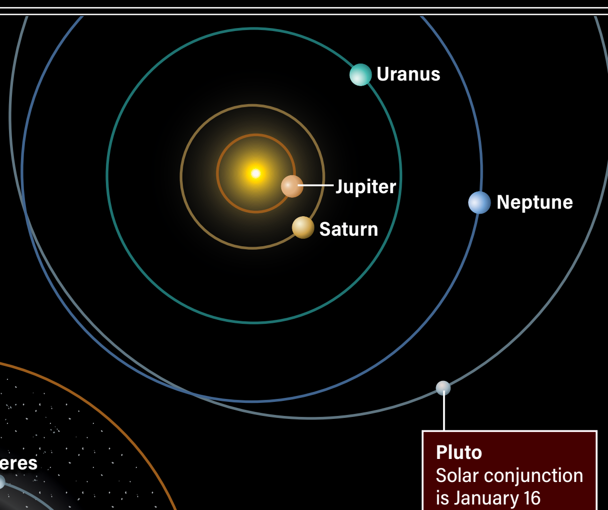
The Moon passes 8° south of Mercury, 7 P.M. EST

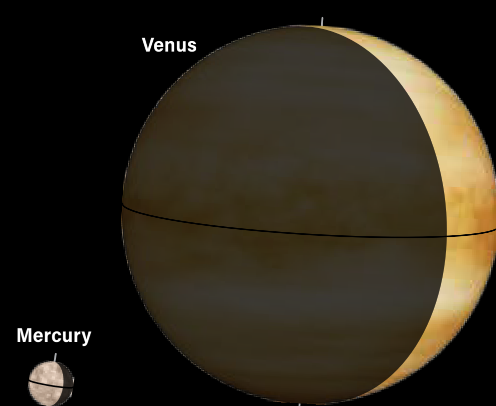
PATHS OF THE PLANETS

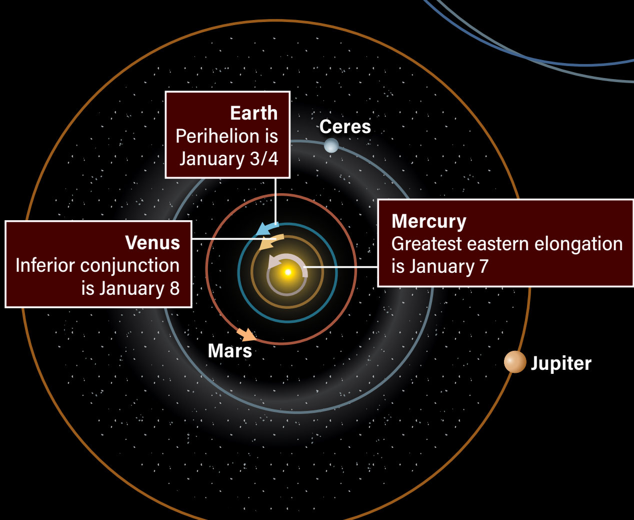


THE PLANETS IN THEIR ORBITS

Arrows show the inner planets' monthly motions and dots depict the outer planets' positions at midmonth from high above their orbits.



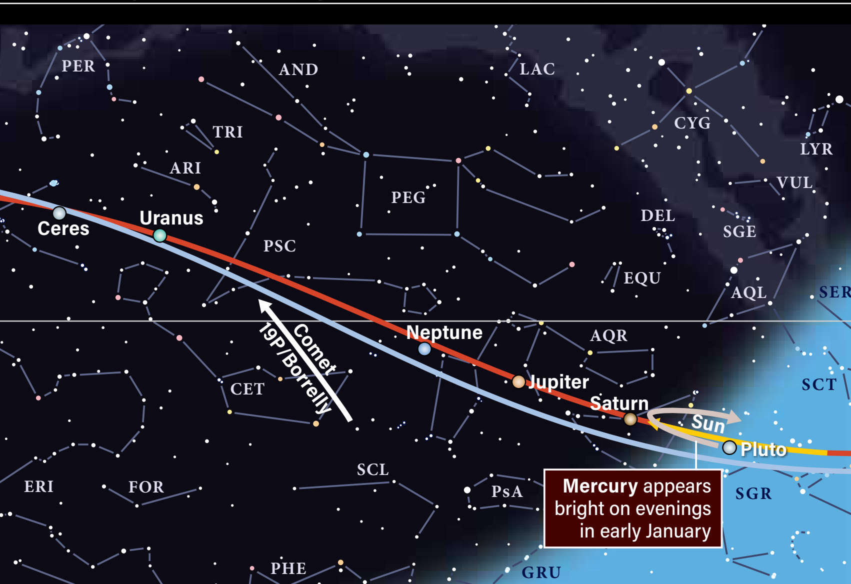




PLANETS	MERCURY	VENUS
Date	Jan. 1	Jan. 31
Magnitude	–0.7	–4.8
Angular size	5.9"	50.0"
Illumination	78%	14%
Distance (AU) from Earth	1.142	0.334
Distance (AU) from Sun	0.363	0.719
Right ascension (2000.0)	20h01.5m	18h44.8m
Declination (2000.0)	–22°22'	–16°15'

JANUARY 2022

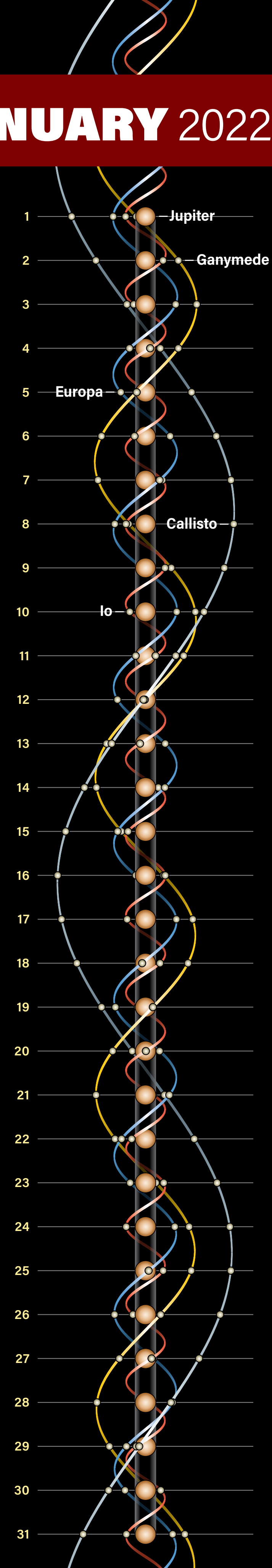
This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.



Early evening

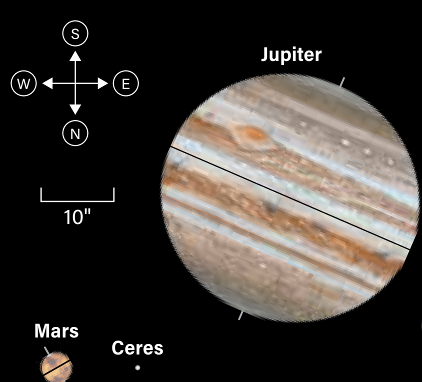
JUPITER'S MOONS

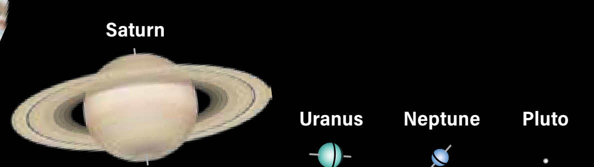
Dots display positions of Galilean satellites at 9 P.M. EST on the date shown. South is at the top to match the view through a telescope.



THE PLANETS IN THE SKY

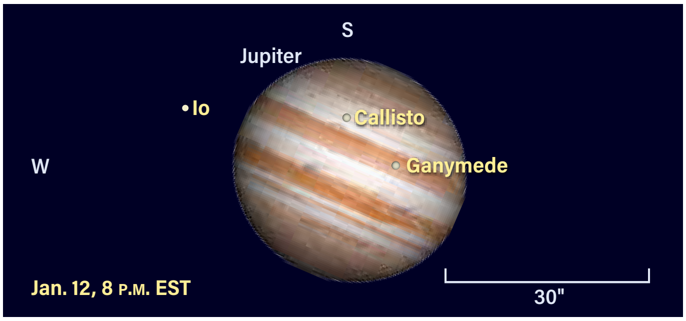
These illustrations show the size, phase, and orientation of each planet and the two brightest dwarf planets at 0h UT for the dates in the data table at bottom. South is at the top to match the view through a telescope.





MARS	CERES	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Jan. 15	Jan. 15	Jan. 15	Jan. 15	Jan. 15	Jan. 15	Jan. 15
1.5	8.0	–2.1	0.7	5.8	7.8	14.8
4.1"	0.7"	34.5"	15.3"	3.6"	2.2"	0.1"
97%	98%	100%	100%	100%	100%	100%
2.265	2.041	5.720	10.844	19.427	30.456	35.426
1.518	2.707	4.990	9.917	19.721	29.920	34.443
17h28.6m	3h42.7m	22h21.7m	21h03.6m	2h32.9m	23h27.5m	19h53.8m
–23°32'	18°27'	–11°17'	–17°39'	14°36'	–4°44'	–22°39'

Dueling moons



Skywatchers this month will be treated to a rare double transit of Ganymede and Callisto. Watch the latter start to catch up with the former as they race across Jupiter's face. Europa, not pictured, lies farther west.

pair of dark equatorial belts in any telescope. The four Galilean moons are on ready display — catch them this month before Jupiter leaves the evening sky in mid-February. It's your last chance before solar conjunction to watch the changing configuration of the four moons.

Although the observing window for seeing satellite transits is narrow, don't miss the Jan. 5 transit of Ganymede's large shadow — the event's long duration (3.5 hours) means most observers across the U.S. will see part of the transit as darkness falls, although you'll need to catch it early if you're in the Pacific time zone. It begins at 6:20 P.M. EST and ends at 9:50 P.M. EST — that's 6:50 P.M. PST for those in the western U.S. As its shadow creeps across Jupiter's face, Ganymede itself stands west of the planet.

Another event not to miss is the Jan. 12 dual transit of Ganymede and Callisto across Jupiter. It's quite rare to catch these two moons transiting together. Callisto's transit begins at 5:22 P.M. EST, followed by Ganymede at 6:50 P.M. EST. Watch as long as you can to see Ganymede catching up with Callisto — the latter's smaller orbit results in faster movement across Jupiter's face.

Also don't miss Io creeping up on the western limb of the planet, disappearing behind Jupiter at 8:36 P.M. EST, an event visible from the western half of the country. In the Pacific time zone, Callisto's transit ends at 6:45 P.M. PST and Ganymede exits the disk at 7:24 P.M. PST.

By Jan. 31, Jupiter stands only 11° high an hour after sunset; such a low altitude makes viewing any planetary details very difficult.

Neptune is a binocular object shining at magnitude 7.8 and located in Aquarius the Water-bearer. It stands halfway up in the southwestern sky Jan. 1 as soon as it's dark. Since Neptune sets mid-evening, try to catch it early. Binoculars are a good first step to finding the planet. Try on Jan. 6, when the crescent moon stands 12° east of Jupiter and Neptune stands 8° northeast of the Moon.

Neptune lies 3.3° northeast of the 4th-magnitude star Phi (ϕ) Aquarii, an easy guide star with two 6th-magnitude stars to its northeast. Neptune moves east along the ecliptic

WHEN TO VIEW THE PLANETS

EVENING SKY
Mercury (west)
Venus (southwest)
Saturn (west)
Jupiter (southwest)
Uranus (south)
Neptune (southwest)

MIDNIGHT
Uranus (west)

MORNING SKY
Venus (southeast)
Mars (southeast)

COMET SEARCH | Bowling across the stars

COMET C/2021 A1 (LEONARD) claimed the title of comet of the year in 2021, but it plummets to 12th magnitude by January's end.

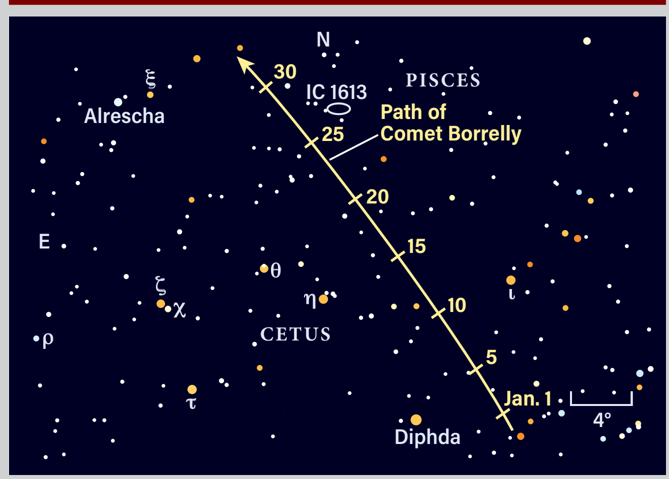
Next up: Nicely placed on the evening stage well to the left of Jupiter is the periodic Comet 19P/Borrelly, floating near Diphda, the 2nd-magnitude nose star of Cetus. Though it's not a contender for this year's title, Borrelly should sport a broad, short fan extending to the south. Even from darker country skies, a 4-inch scope won't show much more than an out-of-round pale gray cotton ball glowing at 10th magnitude. Try magnifications above 100x with a 6-inch to note the well-defined northern flank.

During the bright Moon period from the 5th to the 21st, the geometry barely changes, but a surprise flare-up can never be ruled out. Its close approach to the Sun on Feb. 1 is closer to Mars' orbit than Earth's.

Discovered from France by Alphonse Borrelly in 1904, this comet was the third to be visited by a spacecraft. In 2001, Deep Space 1 unveiled its 5-mile-long bowling pin shape, similar in size to Halley's Comet. Jupiter tugs on Borrelly every 12 years or so, morphing its orbit with each apparition and wreaking havoc on its arrival times into the inner solar system.

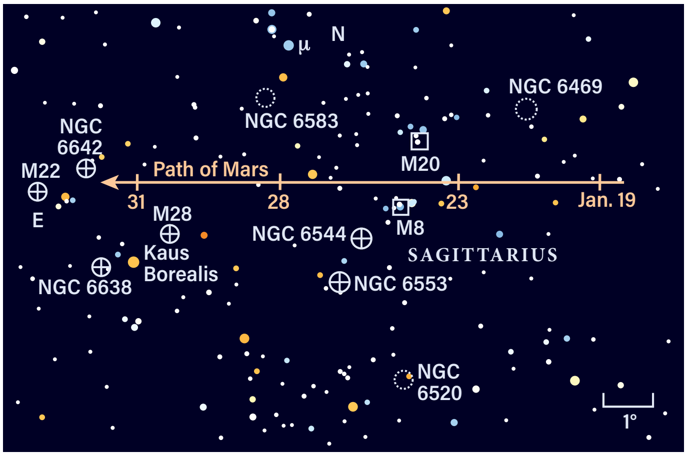
By midnight, the 10th- to 11th-magnitude Comet 67P/Churyumov-Gerasimenko has risen in the east not far from M44, the Beehive star cluster.

Comet 19P/Borrelly



Comet Borrelly spends January in Cetus the Whale. It passes by bright Diphda early in the month and the 10th-magnitude dwarf galaxy IC 1613 toward month's end.

Mars and the Milky Way



Astrophotographers take note: The Red Planet is tracking through a rich field near our galaxy's center rife with targets late this month.

and by Jan. 31, it stands 4° northeast of Phi Aquarii and lies very close (5') to a 6th-magnitude field star. At a huge distance of 2.9 billion miles from Earth, its disk spans only 2" through a telescope. Use high magnification on a steady night of seeing in order to see its bluish-green disk.

Uranus lies about 60° high in the southeastern sky soon after sunset and remains visible until the early morning. It's a binocular object among the stars of Aries the Ram, shining at magnitude 5.8 in a sparse region of the sky. It is about 11° southeast of Hamal, the brightest star in Aries, and 5.3° northwest of Mu (μ) Ceti. Uranus moves westward during the first half of the month, reaches a stationary point Jan. 18, and resumes an easterly trek for the remainder of the month. Uranus spans nearly 4" in a telescope and sports a distinctive greenish-blue hue. This distant ice giant lies 1.8 billion miles away.

While six planets congregate in the evening sky in early January, you have to wait until the predawn hours to catch **Mars**. The Red Planet rises before 6 A.M. local time all month and brightens marginally from magnitude 1.5 to 1.4 during January. Mars is crossing a stunning region of the sky and is worth watching through low-power, wide-field telescopes as it glides past numerous nebulae. It's a challenging object through a telescope, spanning only 4".

Mars lies in Ophiuchus as the new year opens, standing less than 6° northeast of Antares. It crosses into Sagittarius by Jan. 19, about 4° west of the Trifid (M20) and Lagoon (M8) nebulae. The morning of Jan. 25, Mars stands less than 1° south of the Trifid and roughly half a degree away from the Lagoon. On Jan. 26, Mars is less than a Moon's width from the northeastern edge of the Lagoon Nebula — a fine sight through binoculars.

Don't miss the amazing waning crescent Moon on Jan. 29, standing 3° south of Mars an hour before sunrise. They're joined by Venus, only 10.5° to Mars' northeast. Check out these two planets in the midst of the Milky Way. Our galaxy's plane lies at a fairly shallow angle with respect to the southeastern horizon, but observers with suitably clear skies will have fine opportunities for scanning the region with binoculars or capturing some spectacular wide-field photos. The Red Planet ends the month 1.3° northwest of M28, a dim globular cluster (magnitude 6.8), while a brighter (magnitude 5.1) globular cluster, M22, lies 3.5° due east of Mars.

LOCATING ASTEROIDS

Ceres serenades the Bull

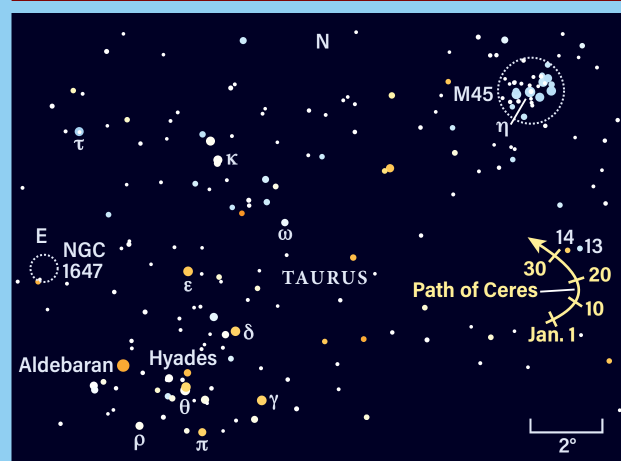
THE FAMOUS DUST CLOUDS surrounding the Pleiades (M45) spread far and wide. They hide many distant stars, helping us locate and track dwarf planet 1 Ceres this month.

The 600-mile-wide interplanetary rock has fallen behind Earth and is slowly fading from magnitude 7.8 to 8.3. This is pretty easy for the smallest telescope from the suburbs, but binocular users will have a tougher time picking out the faint dot.

If you place the Pleiades on the northern edge of your binocular field, to their south you'll see a slightly unequal pair of 6th-magnitude stars: 13 and 14 Tauri. Ceres will be the next brightest dot south of these. It's a slow mover, so it might take a couple of nights to notice the shift against the widely separated anchor stars. Give the search a rest from the 12th to the 14th, as the Moon swells toward Full phase between the Pleiades and Aldebaran.

A treat for small scope users is the five-night passage of 44 Nysa across the Moon-sized sparse star cluster NGC 1647 from Jan. 28 to Feb. 3. You can get there by picturing flipping the Hyades to the other side (northeast) of Aldebaran. At 10th magnitude, Nysa is a perfect clone of several of NGC 1647's cluster members, but within three hours you can pick up its movement relative to the background.

2-for-1 in Taurus



1 Ceres makes a tight turnaround beneath the Pleiades (M45) this month, while 44 Nysa crosses NGC 1647 to its east in late January.

Martin Ratcliffe *is a planetarium professional with Evans & Sutherland and enjoys observing from Wichita, Kansas.* **Alister Ling**, *who lives in Edmonton, Alberta, is a longtime watcher of the skies.*

ANTHONY AYIOMAMITIS

53 The Bubble Nebula ↓

William Herschel first observed NGC 7635 in 1787 as a glow around the magnitude 8.7 star SAO 20575 (cataloged earlier as BD+60°2522). In a telescope, the Bubble Nebula looks more like a comma because the full extent of its spherical shell is so faint that it was only discovered through photography. This emission nebula, which is composed of ionized hydrogen energized by an O-type star, is part of a larger complex of glowing gases.

Viewing the Bubble Nebula requires skies free of light pollution. A Hydrogen-II filter or UHC filter are helpful in bringing out detail. If you observe under extremely dark skies, this nebula can be seen in a 6-inch telescope. It is one of those objects that benefits from increased aperture.

Finding NGC 7635 is easy — it lies about 0.5° from the Cepheus border in Cassiopeia. If you can find the bright open cluster M52, scan less than a degree southwest and you may find the Bubble's pale hydrogen glow. It is equidistant from the HII region NGC 7538, located to the Bubble's northwest. The Bubble Nebula is 15' by 8' with a visual magnitude of about 10, although that light is spread out, making it appear much fainter. A 7th-magnitude star in the area can interfere with an observer's ability to get fully dark adapted.

The star SAO 20575 is the creator of the Bubble Nebula and is estimated to weigh 45 solar masses. Its peculiar spectral classification of O6.5 indicates its surface temperature is a whopping 67,000 degrees Fahrenheit (37,200 degrees Celsius). Astronomers also estimate this star is losing mass at a rate of 1 solar mass every million years. The Bubble Nebula itself marks the edge of a shock wave interacting with the hydrogen atoms in the interstellar medium.

The Bubble Nebula falls within the Cassiopeia OB2 stellar association — a group of young, hot stars that formed together and live fast and die hard. The nebula and stellar association lie some 7,000 to 8,000 light-years from us, in the Perseus Arm. — A.G.

52 Cygnus X-1 ↑

A black hole on a list of the best deep-sky targets? That sounds like an oxymoron! But for the observer who likes to track down the unusual, this is an ideal target. In a telescope, Cygnus X-1 looks like another faint star among many — and to be honest, this is true. But astronomical research shows us that this seemingly insignificant star is so much more.

The first indication it was peculiar was noted in 1964, when a pair of rocketborne Geiger counters discovered an X-ray source. Astronomers traced the X-rays to the 9th-magnitude star HDE 226868 in Cygnus. Its X-1 designation refers to its identification as the first X-ray source in that constellation.

We now know Cygnus X-1 contains a black hole and a star in a binary system. The star is also classified as the variable star V1357 Cygni, a hot supergiant (think Rigel) with an O9.7 spectral classification. Its brightness ranges from magnitude 8.72 to 8.93, though it may fall below 9th magnitude on occasion. Long-term investigations show these brightness fluctuations occur as the star's size varies. When it grows too large, matter is pulled from the outer layers into an accretion disk around the black hole. The star has been fading slightly but steadily since 1999.

Cygnus X-1's claim to fame is that it was the first candidate black hole. In December 1974, two famous theoretical astrophysicists, Stephen Hawking and Kip Thorne, bet each other magazine subscriptions over whether it was a black hole. Thorne was pro, Hawking was con. Thorne ultimately won his one-year subscription to *Penthouse* magazine. Hawking would have won four years to *Private Eye*.

Cygnus X-1 is 7,200 light-years away. While a typical black hole formed from a collapsing star ranges from 3 to 10 solar masses, this one is an estimated 21 solar masses — making it the most massive stellar-mass black hole known. If that isn't cool enough, scientists recently found that the black hole is rotating at close to the speed of light! — A.G.

CHRIS SCHUR

54 The Double Cluster

Known since the earliest days of naked-eye astronomy, the Double Cluster in Perseus appears in the star catalog of Greek astronomer Hipparchus in 130 B.C. The two clusters are now designated h and Chi (χ) Persei (NGC 869 and NGC 884, respectively) and look like nebulous 4th-magnitude stars. One of astronomy history's real mysteries is why Charles Messier listed the Pleiades (M45) and the Beehive (M44) clusters, but not the Double Cluster, in his catalog of non-cometary objects — oops! The earliest use of the Double Cluster moniker seems to be George F. Chambers' 1867 edition of *Descriptive Astronomy*.

Finding the Double Cluster is only challenging when light pollution is significant. Locate Epsilon (ε) and Delta (δ) Cassiopeiae and look southeast about 50 percent farther than the gap between those stars. Even with some light pollution, the Double Cluster should be visible in a finder scope or binoculars.

About 7,500 light-years away, these are some of the most distant naked-eye star clusters. The light you're seeing today comes from a time about 3,000 years earlier than the pyramids in Egypt, just as humans first began smelting copper in the Neolithic period and before the invention of the wheel.

The Double Cluster certainly defines "rich" in terms of star fields. Even the smallest telescopes easily resolve both clusters. Yet larger apertures don't overwhelm the view. Increasing magnification will push one of the clusters out of the field, but its stars are simply replaced by more in the single cluster left.

Both clusters contain young, hot stars sprinkled in with red supergiants like Antares and Betelgeuse. The color contrast of blue and red — observable in many clusters with varying difficulty — is ridiculously easy here. Whether you are using a 3-inch lens or a 12-inch mirror, NGC 869 and NGC 884 are an amazing sight that will impress non-stargazing friends in the backyard after a barbecue. —A.G.

GAÉTAN THIBAULT

CRAIG & TAMMY TEMPLE

55 The Owl Cluster

The names of the members of our solar system date back to antiquity, derived from gods and goddesses. Sometimes an object's name connects to its constellation — the Orion Nebula and Andromeda Galaxy are well-known examples. Other times, an object's shape dictates its name: The Ring Nebula and Whirlpool Galaxy have become proper nouns. And the combination of photography and imagination has birthed even more names, like the North America Nebula or Horsehead Nebula.

But sometimes shape is more subtle and many observers assign the same object different names. This seems to happen a lot these days, mostly because amateur astronomers assign various monikers. NGC 457 is one such example. This rich open cluster in Cassiopeia was named the Owl Cluster by David J. Eicher in the October 1980 issue of this magazine. It is also called the E.T. Cluster, the No. 5 Cluster (for the robot in the movie *Short Circuit*), and the Stick Man Cluster, among others.

Many of Cassiopeia's clusters lie in the Perseus Arm of the Milky Way. (We are in the Orion Spur of the Sagittarius Arm.) The Owl Cluster is slightly more than 7,900 light-years away. It is 13' across and one of the brightest open clusters in Cassiopeia at magnitude 6.4. This brightness makes it surprising that Messier overlooked NGC 457, as M52 and M103 are both magnitude 7.

The Owl Cluster's eyes are Phi (ϕ) Cassiopeiae and HD 7902 (magnitude 5 and 7, respectively). While Phi has been considered a cluster member — and is one of the most luminous stars known — astronomer James Kaler found evidence that this star is between 2,300 and 4,500 light-years away. The Owl's legs and arms are strings of stars that stand out from both cluster members and foreground stars. —A.G.

56 The Whirlpool Galaxy

M51, the fabulous Whirlpool Galaxy in Canes Venatici, is the largest (in apparent diameter) and brightest face-on spiral in the night sky. It sports the iconic visage of what astronomers call a "grand-design spiral galaxy" — one that displays clearly defined and well-organized spiral structure unwinding in orderly fashion from a clear core.

Charles Messier discovered M51 on Oct. 13, 1773; the following January, he recorded it as a "very faint nebula without any stars." In the 1784 *Connaissance des Temps*, Messier appended a reference to Pierre Méchain's observation that M51, in fact, appeared to be a double galaxy with two nuclei. We now know that M51's companion is a diffuse disk galaxy, NGC 5195, that is interacting with it.

Not until 1845 did William Parsons, Earl of Rosse, detect the nebula's "spiral convulsions" with his 72-inch speculum mirror reflector at Birr Castle in Ireland, making M51 the first galaxy shown to have spiral structure. This revelation led to the belief that Rosse had discovered a solar system in formation — a notion that was not shattered until 1923, when astronomers learned the true nature of the mysterious spiral nebulae.

The M51-NGC 5195 pair of galaxies lies 27 million light-years away. M51 is the grander of the two, measuring nearly 90,000 light-years across and shining with a luminosity of about 10 billion suns. NGC 5195 is a small disk galaxy some 55,000 light-years across. It most likely made its closest pass by M51 some 70 million years ago and is now receding from us at a rate of 290 miles per second (467 kilometers per second).

To find these fascinating galaxies, look about 2° south-southwest of 24 Canum Venaticorum. M51 is an 8th-magnitude circular glow (11' by 7'), and NGC 5195 appears as a 6' "knot" a little less than 5' north of M51's nucleus.

M51's spiral structure teases the eye through telescopes smaller than 8 inches in aperture. Larger telescopes bring out the arms, which appear to encircle the nucleus. With patience, those branches break down into finer patches of star-forming regions. Telescopes 10 inches or larger will also clearly show the dusty bridge slicing across NGC 5195's face — a telling sign that the smaller galaxy is receding from the larger. — S.J.O.

RONALD BRECHER

57 M92 ←

One of the northern night sky's superb globular star cluster wonders is our next target: M92 in Hercules. Visible through binoculars as a diffuse star, M92 is a tantalizing sight through telescopes of all sizes. This understated but fascinating cluster rivals the Great Globular Cluster in Hercules (M13; see #69) in wonder, being only a half magnitude fainter and 6' smaller. Both of their brightest stars shine within range of small telescopes (12th magnitude) and can be fully resolved if one can reach to 15th magnitude. M92 "suffers" only in that its core is more compact than M13's, so higher powers and greater patience are required to fully appreciate its glory. As Robert Burnham Jr. noted, if M92 were in any other constellation, it would be considered a showpiece.

Johann Elert Bode discovered the cluster in 1777, saying it was "more or less round, with a pale glow," which hardly does it justice by modern standards. Even Messier resolved no stars in it, noting that the core, however, was "clear and bright" and "resembles the nucleus of a large comet." William Herschel first recognized it as a cluster, while his son John saw this "globular cluster" resolve into "small stars."

Modern studies have shown M92 is a stunning inner halo globular cluster system 27,000 light-years distant — a tad closer than M13 but about 20 light-years smaller. It harbors more than 300,000 suns. Like M13, it can be glimpsed with unaided eyes under a dark sky, just 5° southwest of Iota (ι) Herculis, though it is a more significant feat to see it.

The cluster lies near the farthest point in its orbit around the Milky Way Galaxy — about 32,000 light-years from the galaxy's center — and astronomers believe the 11-billion-year-old system has already made 16 perigalactic transits in its lifetime. Due to these passages, the cluster has periodically been stripped of its stars. In images, M92 exhibits long tidal tails, especially in the northeast-southwest direction along its orbit.

Use high powers to explore the cluster's core and halo, which is strongly asymmetrical to the north, taking the form of a lobster-claw-like arrangement of bright suns. — S.J.O.

58 M4 ↓

Scorpius the Scorpion holds many of the sky's finest deep-sky objects, including the spectacular globular cluster M4. This group of stars stands out for several reasons. First, at 7,200 light-years away, it is the closest globular cluster to our solar system. It's also on the small side as globulars go, measuring about 75 light-years across. For comparison, the Hercules Cluster (see #69) and the grandmaster of globulars, Omega Centauri (see #27), both span roughly 150 light-years in diameter.

Among the 100,000 or so stars that call M4 home is a hidden treasure: the pulsar PSR B1620–26. A member of a binary system, PSR B1620–26 is teamed up with a white dwarf. Researchers have confirmed that an exoplanet orbits these two stellar remnants. Because it is thought that planets form shortly after their parent stars, and because M4 is estimated to be around 12 billion to 13 billion years old, this is one of the oldest exoplanets yet found.

M4 earned a footnote in astronomical history by being the first globular cluster ever resolved. It was also the only globular out of the 29 included in Messier's catalog that he was able to resolve into stars.

Best of all, it couldn't be easier to find. M4 is nestled just over a degree west of brilliant Antares (Alpha [α] Scorpii), the heart of the Scorpion. Using low power, shift Antares so it's just outside the eastern edge of your field and you'll see the cluster's spherical form take shape. Even an old 2.4-inch refractor can resolve some stars at 50x.

With a 4-inch aperture or larger, a curious feature appears. M4 displays a bright bar cutting right across the center of its disk, seemingly separating the cluster into two halves. Try a moderate magnification around 75x to 100x for the best view of this divide, which is the result of a chain of 11th-magnitude cluster stars that just happen to line up in a row. — P.H.

TONY HALLAS

DAN CROWSON

KFIR SIMON

59 Albireo ↑

One of the sky's finest binary stars for backyard scopes, Albireo (Beta [β] Cygni) marks the head of Cygnus the Swan, making it easy to find on summer and autumn nights.

It may look like just another star to the naked eye, but aim a telescope its way and it becomes clear why Albireo is considered a supreme showpiece for small scopes. There, set against a glorious Milky Way field, we find the brighter star, golden 3rd-magnitude Albireo A, attended by sapphire-blue 5th-magnitude Albireo B. The color contrast is dazzling. They appear separated by 35", which makes them resolvable even in steadily held 10x binoculars.

Albireo A, the system's primary star, is a bright spectral class K helium-fusing giant. It's about 50 times larger in diameter than our Sun, and contains some five times the mass. Although its luminosity is 950 times greater than the Sun's, its surface temperature is slightly lower at 7,500 degrees Fahrenheit (4,150 degrees Celsius).

Albireo B, meanwhile, is a class B hydrogen-fusing main sequence star with a sweltering surface temperature of 21,300 F (11,800 C). It's using up its hydrogen fuel quickly, producing a luminosity 190 times greater than that of the Sun. Because Albireo B is 3.3 times more massive than the Sun, its lifespan will also be shorter than our own star's.

When the famous double-star observer F.G.W. Struve first examined Albireo in 1832, he measured the apparent distance to the blue companion star from Albireo A as 34". The stars have changed little since. This has led some to debate whether they form a genuine binary system or are just a chance line-of-sight optical double star. If they do form a physical pair, then Albireo B must be at least 4,400 astronomical units (AU; 1 AU is the average Earth-Sun distance) from Albireo A. At such a tremendous distance, its orbital period would have to be at least 100,000 years.

Research has also uncovered that Albireo is actually a triple-star system. Gleaming Albireo A is accompanied by another blue star separated by only 0.4" and referred to as Albireo Ac. — P.H.

DAN CROWSON

60 M94

Nestled between the two brightest stars in Canes Venatici lies M94, a beautiful spiral galaxy 16 million light-years distant.

Pierre Méchain discovered M94 on March 22, 1781, and communicated its position to Charles Messier. Messier saw a "nebula" with a bright center surrounded by a condensed halo. But William Parsons, Earl of Rosse, found the "nebula" broken into patches — suggesting that the "object will probably turn out to be a spiral" — with "much faint outlying nebulosity."

Lord Rosse's words were prophetic. M94 is a nearly face-on early spiral galaxy that only 10 million years ago may have experienced a violent explosion, which disgorged millions of solar masses of material. The galaxy possesses a curious multi-layered appearance, including a central "spiral" about 30,000 light-years across with a broad, faint outer ring some 40,000 light-years farther out. This outer "ring" is actually two giant, star-forming spiral arms extending from the galaxy's inner disk.

M94's tightly wrapped inner arms appear yellowed with age and show little evidence of recent star formation. In contrast, the galaxy's nuclear region reveals an unusual starburst ring and two point sources, both bright in ultraviolet light. This suggests that two objects — compact star clusters or supermassive black holes — are in the final stages of merging.

Under moderate to high powers through a telescope, the 8th-magnitude galaxy's disk becomes a hypnotic sight: Its bright core with a central pip, surrounded by a soft gel-like elliptical disk, looks like an eye staring back at you. The galaxy's dim outer rings can be spied through 4-inch telescopes under dark skies as a soft halo of light. Larger apertures will resolve its ringlike structure more clearly. —S.J.O.

61 The Triangulum Galaxy

Named for the constellation in which it appears, the Triangulum Galaxy (M33) is the third largest member of the Milky Way's Local Group of galaxies. Only the Andromeda Galaxy (see #100) and the Milky Way are bigger.

M33 lies about 2.7 million light-years away. And like its hefty galactic neighbors, it is a spiral galaxy. However, unlike Andromeda and the Milky Way, both of which are classified as barred spirals, the Triangulum Galaxy does not exhibit a central bar-shaped structure. Its spiral arms instead extend directly from its core. The arms of Triangulum are also less tightly wound than those of Andromeda and the Milky Way, stretching out across some 50,000 light-years, or about half the diameter of our own galaxy. M33 holds roughly half as many stars as the Milky Way.

Unlike Andromeda, which we see nearly edge-on, Triangulum presents itself almost face-on. This affords astronomers a great opportunity to study a nearby spiral's structure.

Many ionized HII regions are scattered across Triangulum's disk. These pockets of glowing hydrogen gas come to life in photos taken through large ground-based telescopes and the Hubble Space Telescope. The largest HII region in M33 is separately cataloged as NGC 604. Astronomers estimate this massive star-forming borough stretches across more than 1,500 light-years, making it at least some 40 times larger than our own Orion Nebula.

While observers have closely scrutinized the Triangulum Galaxy since its discovery, it's ironic that it often eludes amateurs trying to spot it for the first time. Even though it is rated at 6th magnitude, M33 has a very low surface brightness due to its large apparent diameter in our sky. That causes it to blend seamlessly into the background. Many searching for M33 pass right over it without even noticing.

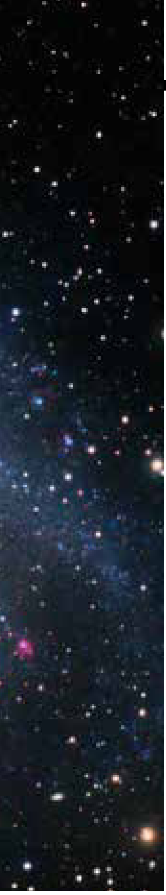
It's easier to spot the galaxy's glow through the wider fields of binoculars and finder scopes. If you are targeting it through a telescope, however, use averted vision and your lowest-power eyepiece for the best view. Then, once you find the galaxy, try tracking down NGC 604. It will look like a small glowing patch just northeast of M33's core. —P.H.

ADAM PHILLIPS

62 M63

Among the heavens' most beautifully haphazard galaxies is M63, the Sunflower Galaxy. This massive, curdled spiral sports only two arms, but their flocculate (feathery or disjointed) nature makes them hard to define. M63 is nicknamed the Sunflower Galaxy because of its resemblance to the dense, seedy head of that towering plant, which is ringed by an abundance of bright, overlapping petals. In images, it's the vast infiltration of dust that largely allows the eye to trace out the spiral's structure, which shows up more clearly in infrared images.

M63 was a Pierre Méchain discovery. A contemporary of Charles



JEFFREY WEISS

63 Small Magellanic Cloud →

Like its companion, the Large Magellanic Cloud (LMC; see #80), the Small Magellanic Cloud (SMC) is a remarkable spectacle enjoyed by Southern Hemisphere astronomers. It is visible to the unaided eye as a hazy glow. But at 4° by 3° in size, it is fainter and smaller than the LMC. The neighboring clouds are located 22° apart in the sky, with the SMC the more southerly of the pair. In fact, the SMC is so far south that it remains invisible from all of North America except southernmost Mexico.

Studies tell us the SMC is about 200,000 light-years away, about 7,000 light-years across, and hosts several hundred million stars. Even through modest binoculars, the SMC's unusual shape is evident. Some have likened it to a fishhook or a comma, with a broader, brighter portion of the satellite galaxy extending toward the south. That appearance has also led astronomers to suggest that the SMC may have once been a modest barred spiral whose structure was morphed by tidal forces from both the Milky Way and the LMC.

Both Magellanic Clouds played an important role in our understanding of the size and structure of the universe. During her studies of variable stars in the clouds more than a century ago, Henrietta Swan Leavitt of Harvard College Observatory found that several showed a relationship between their period of variability and energy output, or luminosity. These stars, called Cepheids, all share a distinctive characteristic: the longer the period, the greater the star's luminosity. By knowing the brightness and period of a Cepheid, astronomers can calculate its distance. Cepheids have been found in galaxies as far away as 60 million light-years away, making them a fundamental tool for gauging cosmic distances.

Decades ago, astronomers proposed that the SMC was splitting in half. This was more recently confirmed thanks to the Gaia spacecraft. The stars in the southeastern portion of the SMC are slowly being pulled toward the LMC. And any of the SMC's remnants will likely be absorbed into the Milky Way itself. Eventually, the SMC will be no more. — P.H.

FERNANDO OLIVEIRA DE MENEZES

JOHN CHUMACK

64 The Wild Duck Cluster ←

The summer sky is for the birds — literally. There is Cygnus the Swan, Aquila the Eagle, the Eagle Nebula, and even a flock of wild ducks within the small constellation Scutum the Shield.

The Wild Duck Cluster (M11) was discovered in 1681 by German astronomer Gottfried Kirch, who described it as "a small, obscure spot with a star shining through." It wasn't until 1733, however, that English Clergyman, philosopher, and scientist William Derham resolved Kirch's obscure spot into countless stars.

M11 is some 6,100 light-years away and covers a region some 23 light-years across. That places it in the Sagittarius arm of the Milky Way, along with such deep-sky treasures as the Eagle Nebula and the Omega Nebula. Discovering M11 for yourself is most easily done by first locating Aquila the Eagle's diamond-shaped body and then its tail-feather stars, Lambda (λ) and 12 Aquilae. These team up with Eta (η) Scuti to form a three-star arc that curves right toward M11.

The Wild Duck Cluster takes its nickname from the V-shaped pattern formed by its brighter stars. Describing the appearance in his 1844 classic book *A Cycle of Celestial Objects*, Admiral William Smyth wrote that the cluster "somewhat resembles a flight of wild ducks in shape." Although this analogy might be true through smaller telescopes, it's lost through scopes much larger than 6 inches in aperture.

M11 is one of the richest and most compact open clusters found anywhere in the sky. By some counts, it contains more than 2,900 stars. While most stars in M11 shine at magnitude 10 and below, the single star that Kirch noted shines at 8th magnitude. This star is a hot blue main sequence star — as are many others in the cluster. There are also several red and yellow giants sprinkled throughout, adding splashes of color to the scene. Based on studying those giants, astronomers have pegged M11's age at around 220 million years. — P.H.

Messier, Méchain was an astute observer but had no interest in cataloging new nebulae and clusters. He did, however, communicate them to Messier, who, in turn, checked their positions, and added them to his catalog with credit. William Parsons, Earl of Rosse, discovered its spiral structure, making it one of 14 "spiral nebulae" discovered by 1850. He had no idea, however, of their true nature.

At 100,000 light-years across, M63 rivals our Milky Way in size, but its structure is different. M63 has no central bar and only moderate to loosely wound arms. The galaxy displays strong spiral structure from its nucleus out to around 10,000 light-years; after that, there is a significant lack of cohesion. Within its lenticular nuclear region lies an active galactic nucleus and several young star clusters. A dim system of arches and "plumes" blossom from the galaxy's periphery, suggesting the galaxy consumed a dwarf companion in the last few billion years. Recent studies have shown about a dozen additional dwarf galaxies gravitationally bound to M63 — perhaps tempting, appetizing morsels for this extragalactic cannibal.

To find M63, look about 1½° north-northwest of 20 Canum Venaticorum, which shines at magnitude 4.5. Moderate-sized telescopes will show this milky white glow sporting an intense starlike nucleus within a mottled disk, which appears to form a ring around the lenslike nuclear region. The galaxy's inner spiral arms are best left to larger telescopes and astrophotographers. — S.J.O.

65 The Blackeye Galaxy →

CHRIS SCHUR

Extragalactic pugilist M64, the Blackeye Galaxy in Coma Berenices, sports a massive shiner of dust that lies asymmetrically across the galaxy's prominent bulge. Apparently, M64 met another galaxy over a billion years ago and did not so much battle it as assimilate it. Nevertheless, that feisty dwarf system caused significant turbulence in M64: The stars and gas in M64's inner disk rotate in the opposite direction as its outer regions.

Compression during the merger likely ignited bouts of regional star formation in the galaxy's bulge, where youthful stars contribute a blue tint. This contrasts nicely with the red tint found at the galaxy's core, which is rich with older stars. Cataloged distances to M64 vary, but recent estimates put it at between 14 million and 24 million light-years away.

English astronomer Edward Pigott discovered M64 on March 23, 1779. Twelve days later, German astronomer Johann Elert Bode independently sighted it as a "small nebulous star." Pigott's observation, however, was not made public until it was read before the Royal Society of London in 1781. Messier was unaware of this find when he prepared his final catalog. Consequently, Pigott's discovery remained in the shadows until 1907, when French astronomer Guillame Bigourdan linked Pigott's reported position of the "nebula" to M64.

To find this intriguing galaxy, look just 1° northeast of 5th-magnitude 35 Comae Berenices. Under a dark sky, the magnitude-8.5 galaxy appears as a tiny puff of light through 10x50 binoculars. Small telescopes will show its smooth, oval disk (10') punctuated by a bright core of light. The disk also has a milky sheen and a blue-white color.

The galaxy takes magnification well. High power is required to see its black eye, which skilled observers have glimpsed through apertures as small as 2.4 inches. Moderate-sized telescopes and high magnification, however, are generally required to show this dust patch well. Look for a subtle absence of light, rather than an intense darkness. At 240x, John Herschel called it a "vacuity below the nucleus." (Curiously, at 320x, he thought the nucleus resembled a double star.) Seeing the galaxy's pinwheel arms requires larger apertures, as well. — S.J.O.

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66 Alpha and Proxima Centauri ↓

The third-brightest star in the sky, Alpha (α) Centauri, gleams in the southern constellation Centaurus. Since it is positioned at a declination of almost –61°, only stargazers located south of latitude 29° have any hope of seeing it. But those who can will never forget their first glimpse. Proximity is the main reason this star, also known as Rigel Kentaurus, appears so bright in our sky. At just 4.37 light-years away, it's our nearest stellar neighbor.

When we look at Alpha Centauri, we're not seeing a single star, but a triple-sun system. The biggest and brightest member of this stellar family, shining at magnitude 0, is Alpha Centauri A, a type G main sequence star like the Sun. Alpha Centauri B, an orange type K star, glows at magnitude 1.3 and orbits A once every 79.9 years. Their apparent separation varies from just 2" to 22" throughout each orbit. The stars are now slowly creeping closer to one another as seen from Earth, having passed their maximum separation, or apastron, in 1995. Their next closest approach, or periastron, is in 2035.

At 4.24 light-years distant, the third star in the system, Proxima Centauri, is slightly closer to us than the other two. But being a tiny red dwarf star, Proxima is far fainter than our naked eyes can detect. It shines at only magnitude 10.4, appearing as a dim red speck about 2° southwest of the brighter Alpha pair.

ALAN DYER

However, in 2016, Proxima outshone both Alphas in the news when astronomers announced the discovery of an extrasolar planet orbiting the petite sun. Dubbed Proxima Centauri b, it's about 25 percent more massive than Earth. And even though its orbit is equivalent to about one-eighth the distance between Mercury and the Sun, it resides within Proxima's habitable zone, where liquid water could exist on the planet's surface. Still, odds of life spawning there are considered slim. Proxima sometimes produces massive flares, bathing the planet's surface in lethal levels of radiation.

A second planet, Proxima Centauri c, was discovered four years later. It is about seven times the mass of Earth and orbits outside Proxima's habitable zone. — P.H.

WAGNER AMARAL

67 The Carina Nebula

The Orion Nebula (see #19) may be the best-known emission nebula, but it loses to the Carina Nebula (NGC 3372) as the most spectacular. Measuring 2° across, the Carina Nebula looks like an ethereal orchid blossoming, with many dark rifts dividing it into several distinct "petals."

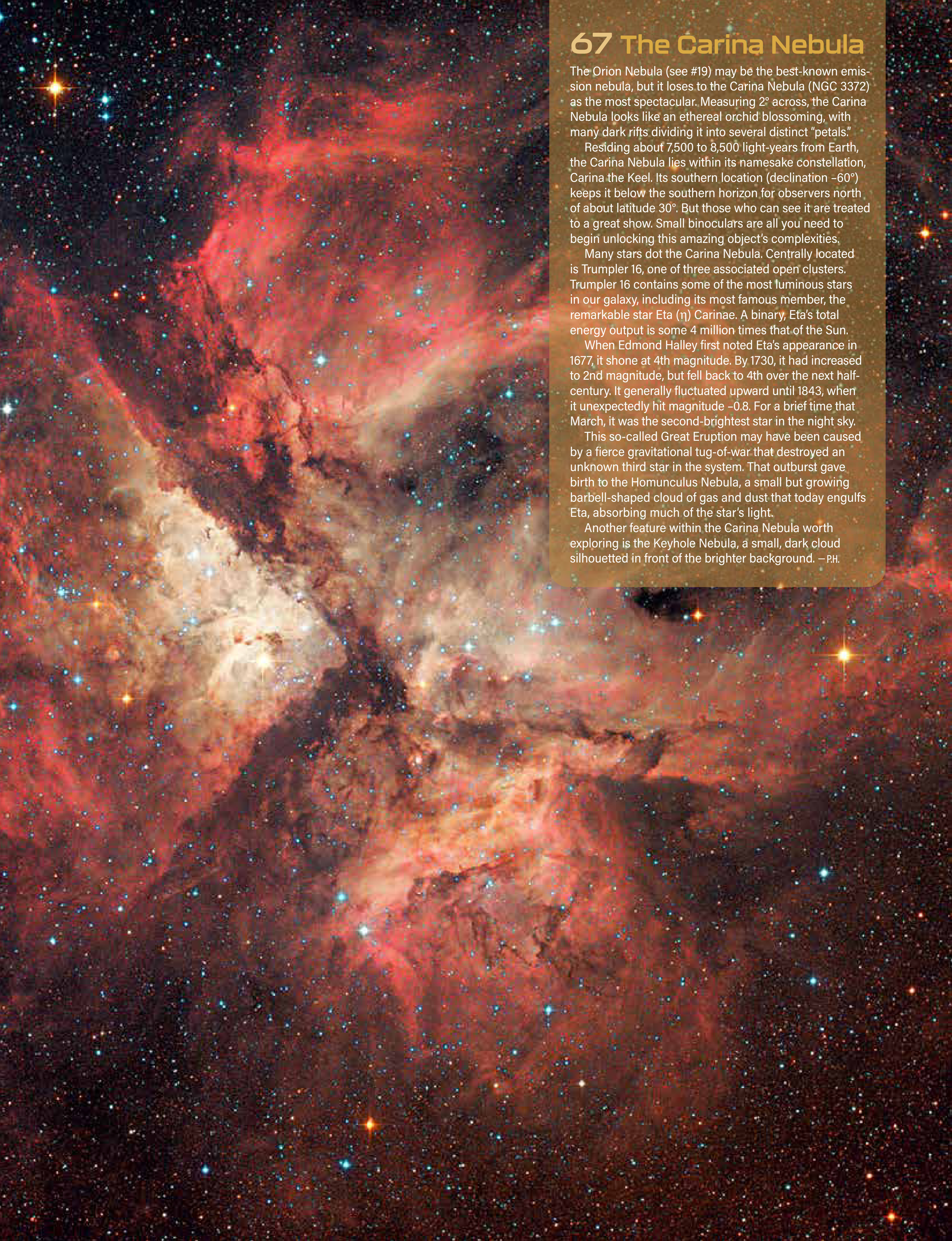
Residing about 7,500 to 8,500 light-years from Earth, the Carina Nebula lies within its namesake constellation, Carina the Keel. Its southern location (declination –60°) keeps it below the southern horizon for observers north of about latitude 30°. But those who can see it are treated to a great show. Small binoculars are all you need to begin unlocking this amazing object's complexities.

Many stars dot the Carina Nebula. Centrally located is Trumpler 16, one of three associated open clusters. Trumpler 16 contains some of the most luminous stars in our galaxy, including its most famous member, the remarkable star Eta (η) Carinae. A binary, Eta's total energy output is some 4 million times that of the Sun.

When Edmond Halley first noted Eta's appearance in 1677, it shone at 4th magnitude. By 1730, it had increased to 2nd magnitude, but fell back to 4th over the next half-century. It generally fluctuated upward until 1843, when it unexpectedly hit magnitude –0.8. For a brief time that March, it was the second-brightest star in the night sky.

This so-called Great Eruption may have been caused by a fierce gravitational tug-of-war that destroyed an unknown third star in the system. That outburst gave birth to the Homunculus Nebula, a small but growing barbell-shaped cloud of gas and dust that today engulfs Eta, absorbing much of the star's light.

Another feature within the Carina Nebula worth exploring is the Keyhole Nebula, a small, dark cloud silhouetted in front of the brighter background. – P.H.



68 Stephan's Quintet ↓

Stephan's Quintet sits just 0.5° southwest of NGC 7331, making it one of the easiest tight groups to find. Halton C. Arp listed this compact group as Arp 319 in his 1966 *Atlas of Peculiar Galaxies*. Later, he used NGC 7320's anomalous redshift — much lower than the others' in the group, indicating it is much closer — to question the validity of redshift as a reliable measure of distance. But Hubble Space Telescope observations dismissed his concerns, as NGC 7320 resolves into stars, while the Quintet's four other galaxies do not. This proves NGC 7320 is indeed an interloper not physically part of the crowd: NGC 7320 is a small Sb galaxy 39 million light-years away. NGC 7317, NGC 7318A, NGC 7318B, and NGC 7319 are 7.5 times more distant.

NGC 7317 is a magnitude 13.6 E1 elliptical galaxy roughly 1' across. Magnitude 14.4 NGC 7318A is listed as either Sc or E2, and is a compact 0.9'. It sits behind NGC 7318B. These two are interacting, surrounded by disturbed gas and dust. NGC 7318B is a magnitude 13.9 barred spiral with dimensions of 1.9' by 1.2'. Hubble photographs show twisted arms rich in HII regions, blue stars, and dark nebulae, particularly along one of its arms, which has been stretched by gravitational interactions.

NGC 7319 is a 14th-magnitude SBbc galaxy whose arms have also been highly disturbed by interactions. It is a type 2 Seyfert galaxy with an energetic core. NGC 7320 is a magnitude 13.6 galaxy spanning 2.2' by 1.1'. Despite its proximity to the Local Group, it shows little detail beyond a brighter central hub.

Stephan's Quintet is very small and easy to overlook when scanning around NGC 7331. Telescopes 12 inches and larger — and very dark skies — are ideal to resolve its members and to look for nuclear brightening. — A.G.

DAN CROWSON

69 The Hercules Cluster ↑

The Hercules Cluster (M13) is often cited as the grandest globular cluster north of the celestial equator. Located 25,000 light-years away, it hosts more than 100,000 stars crammed into a volume of space roughly 150 light-years in diameter.

Although it is visible to the naked eye on dark, transparent nights, it seemingly went undocumented until Edmond Halley first laid eyes on it in 1714. Charles Messier subsequently added it to his famed catalog (as entry 13) a century later, but he only described it as a starless nebula since his telescopes were incapable of unlocking any stars within. That task was left to William Herschel, who also coined the term *globular cluster*.

The easiest way to locate M13 using either binoculars or a telescope is to draw an imaginary line between the bright stars Vega (Alpha [α] Lyrae) in Lyra, to M13's east, and Arcturus (Alpha Boötis) in Boötes, to its west. M13 is about one-third of the way from Vega to Arcturus, along the western side of the Hercules Keystone, which is a trapezoidal asterism formed by four bright stars.

M13 is a beautiful sight through any telescope. A 4-inch scope will begin to show that there is much more here than just a nebulous glow, as the cluster's edges begin to dissolve into myriad points. Doubling the aperture causes M13 to explode into a huge globe of tiny stars. If you have an 8-inch or larger scope, look carefully and see if you notice how the outer members form chains, or lines, radiating outward from the cluster's core. Their appearance reminds many of the legs of a spider.

Those same larger scopes reveal an intriguing feature first discovered around 1850 by Bindon Stoney, an astronomer working for William Parsons, Earl of Rosse, at Birr Castle in Parsontown, Ireland. Near the cluster's core, he noticed three subtle, comparatively star-poor lanes spaced about 120° apart that seemingly intersect to roughly form the letter Y. Some today refer to these as propellers. — P.H.

JOHN CHUMACK

DAN CROWSON

70 M82 ↑

M82 — also known as the Cigar Galaxy — and neighboring M81 (see #92), together make up of the night sky's dynamic duos. M82 is one of the closest (12 million light-years) examples of an edge-on system in starburst chaos. In images, it appears like an extragalactic radical, with spiked "hairs" bristling off a cigar-shaped body tattooed with invisible dark matter.

German astronomer Johann Elert Bode discovered this "nebulous patch" on the same night as M81, noting its elongated form. In 1871, William Parsons, Earl of Rosse, noted curious dark bands crossing its length. Later astronomers suspected the galaxy was experiencing violent explosions — and they were right. We now know its central region is the site of intense starburst activity, with 40 or so supernovae in the early stages of expansion.

Starburst galaxies create stars at a rate tens or even hundreds of times faster than normal galaxies. A brush with M81 hundreds of millions of years ago triggered this stellar chaos, making the galaxy five times more luminous than our Milky Way. In red-sensitive images, long filaments stream out at right angles from the galaxy's central region to about 34,000 light-years. Enormous galactic winds and gas outflows are transporting up to some 50,000 suns of gas and dust into intergalactic space.

Through the telescope, M82 is a stunning sight, like a ghostly starship, cracked and floating through an interstellar graveyard. Immediately noticeable is that its western half is distinctly brighter than the eastern half. Most impressive are the energetic-looking bursts of starlight running lengthwise through most of the galaxy. Does the core look angular to you? If so, it's an illusion created by wedgelike lanes of dust. — S.J.O.

TERRY HANCOCK/TOM MASTERSON

71 Flaming Star Nebula ←

John Martin Schaeberle discovered IC 405 near the end of the 19th century. The object was independently spotted shortly after by astrophotographers Max Wolf and Eugen von Gothard. It's located in Auriga, a constellation better known for its wealth of open clusters, but whose nebulae are often overlooked.

Also known as the Flaming Star Nebula, this object is a combination of emission and reflection nebulae illuminated by the unusual variable star AE Aurigae. The nebula is a large 37' by 19' across, and its brightest portion sits east of the star. IC 405 lies 1,500 light-years away.

Many objects with low surface brightness that were discovered via early astrophotography are visible with today's amateur telescopes, which are often better than those that deep-sky observers in the late 19th and early 20th centuries were using. *The Index Catalogue* (from which the IC number is derived) description of the Flaming Star Nebula reads, "star of 6.7 magnitude with pretty bright, very large nebula." With a description like that, you'd think it would be simple to spot. But like many expansive nebulae, it isn't as easy as it sounds. Under dark, dry skies, IC 405 can be seen with telescopes as small as 2.4 inches. But in less ideal skies, it may be impossible to see, even with larger apertures. Winter nights tend to have lower humidity, so if you enjoy bundling up and observing under frigid temperatures and dark skies, you have a good chance of picking up this nebula.

If you've got weird stars on your bucket list, AE Aurigae is another reason to seek out IC 405. This extremely hot O9.5 star varies a modest 0.7 magnitude (from roughly 5.4 to 6.1), but its real claim to fame is its velocity through space. It is one of two stars ejected during a collision of two binary systems about 2 million years ago in the region where the Orion Nebula's Trapezium (see #19) now resides. The other is Mu (μ) Columbae. A third star, 53 Arietis, originated in that same region, but was ejected a few million years earlier. AE Aurigae is currently flying by IC 405, illuminating the gas as it goes. Once it passes, the nebula will fade. — A.G.

ADAM BLOCK

72 M78 ←

Wonderfully mysterious, M78 is the brightest swath of nebulosity in a group of specterlike glows some 2½° northeast of Alnitak (Zeta [ζ] Orionis), the eastern star in Orion's Belt. Pierre Méchain discovered M78 in early 1780 and wrote to Charles Messier that the nebula surrounded two "fairly bright nuclei." These nuclei are two 10th-magnitude stars (HD 38563A and HD 38563B), and the chief illuminators of the surrounding nebulae. While the ultraviolet radiation streaming from these stars is not hot enough to cause the nearby gas to glow, their light does scatter off dust particles, making them shine by reflected light.

Messier resolved M78 into a "[c]luster of stars, with a lot of nebulosity," while William Parsons, Earl of Rosse, added it to his list of spiral nebulae. However, in wasn't until 1919 that Vesto Slipher at Lowell Observatory took its spectrum and found its true nature was a reflection nebula. Lord Rosse was likely seeing arcing filaments of dust that curl around the central stars, giving it a pseudo-spiral form.

These dark bands also divide the shining clouds into sections, which we see as the nebulosities NGC 2064, NGC 2067, NGC 2071, and McNeil's Nebula (which flares into view only when its illuminating variable star V1647 Orionis experiences an outburst). All are associated with the Orion Molecular Cloud Complex some 1,350 light-years distant, which includes the Orion Nebula (see #19).

M78 shines at 8th magnitude and measures 8' by 6' — about as large as M77 (see #89) in Cetus and a magnitude brighter! Under a dark sky, it is visible through binoculars. Small telescopes will show its two 10th-magnitude stars burning through the nebulosity like bloodless eyes peering through a frosty window. Larger telescopes at moderate to high magnifications will shatter the nebulosity into bright fans, wisps, and streamers tickled by dark skeletal fingers of dust. Unseen to our eyes are the clusters with hundreds of newborn stars embedded deep within the nebula's dusty folds, as well as a family of 45 infant T Tauri stars less than 10 million years young, whose cool cores have yet to ignite. —S.J.O.

73 Copeland's Septet →

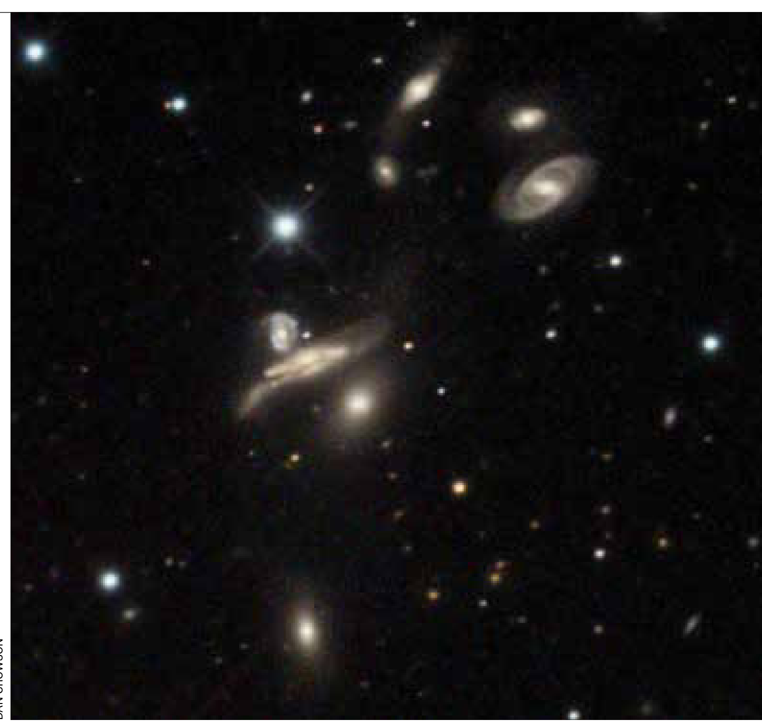
When it comes to obscure objects, Copeland's Septet (also called Hickson Compact Group 57) ranks with the best of them. Ralph Copeland discovered this group in the spring of 1874 while employed by William Parsons, Earl of Rosse, in Ireland. He was using the Leviathan, a 72-inch speculum mirror telescope at Birr Castle. At that time, it was the largest telescope in the world, enabling him to pick up faint galaxies with relative ease.

Located 3° northwest of 93 Leonis, this group is unusual in that it is dominated by barred spirals. A 12th-magnitude foreground star sits in the middle. NGC 3753 is the brightest and largest member. Also called Hickson 57a, it is magnitude 13.6 and appears edge-on, covering 1.7' by 0.4'. In images, it sports a dark lane; blue, knotty arms; and faint extensions that may be associated with a collision and appear to stretch hundreds of thousands of light-years to neighboring NGC 3746.

NGC 3746 (Hickson 57b) is the group's second-largest member. This magnitude 14.2 galaxy has produced two recorded supernovae: 2002ar and 2005ba. A barred spiral, this galaxy has a more distinct inner ring and S-shaped spiral halo than fellow group member NGC 3745. The latter is a tiny (0.4' by 0.2') magnitude 15.2 barred spiral also cataloged as Hickson 57g. Photos show it as compact with an extended faint spiral halo.

Although comparable to NGC 3745 in size, NGC 3754 (Hickson 57d) is magnitude 14.3. NGC 3748 (Hickson 57e) is a magnitude 14.8 edge-on lenticular or Sa-type spiral with a narrow dust lane. It spans 0.7' by 0.4'. NGC 3750 (Hickson 57c) is a magnitude 13.9 lenticular galaxy 0.8' by 0.7' in size. It shows little structure in photos. NGC 3751 (Hickson 57f) is as bright as NGC 3750 and an elongated 0.8' by 0.5'. An eighth member, the barred spiral PGC 36010 with a magnitude of 17.4, was too faint for Copeland to observe. —A.G.

DAN CROWSON



ANDREI PLESKATSEVICH

74 IC 1396 ←

Cepheus is a rich region of the Milky Way with many emission nebulae. One of the largest, IC 1396, could be called the Northern Rosette (see The Rosette Nebula, #6) because it resembles the more famous nebula in Monoceros. IC 1396 is about 3° wide, with a hollow interior showing minimal nebulosity. This fascinating object sits some 2,400 to 3,000 light-years away.

The nebula is illuminated by hot stars in its gas-poor interior, where the radiation has physically pushed the gas away. This star cluster is less conspicuous than NGC 2244 in the true Rosette Nebula. The brightest parts of IC 1396 are its northwest and eastern edges. Photographs show a complex of dark nebulae threaded throughout the perimeter. Many of the dust structures are aligned so they appear to radiate away from the stars in the nebula's core. Those that don't are likely on our side of the roughly spherical nebular shell. Six of the dark nebulae were discovered by Edward Emerson Barnard: In order of decreasing size, they are B160, B161, B365, B163, B162, and B367.

IC 1396's most famous feature is IC 1396A, better known as the Elephant Trunk Nebula. The trunk of this dark nebula is formed by an irregular pillar of dust many light-years long. Some observers find it easier to spot than the Horsehead Nebula (see #28) — another (arguably more famous) dark nebula — because the Elephant Trunk is larger.

On IC 1396's northern edge is Herschel's Garnet Star (Mu [μ] Cephei). This supergiant star is similar to Mira and is the archetype of a class of semi-irregular variables called Mu Cepheids (not to be confused with Cepheids, named after Delta [δ] Cephei). Mu varies between magnitude 3.4 and 5.1 over the course of two to two and a half years. This spectral type M2 star is a colorful contrast to the gray nebula.

Some observers report the nebula is visible as a magnitude 5.6 gray patch with naked-eye averted vision. Others instead give its surface brightness, or brightness per unit of area, as about 14 magnitudes per square arcminute. If you observe under exceptionally dark skies, add it to your list of targets. You can decide how bright it appears. — A.G.

75 M15 →

While most of the Milky Way's globular clusters are found in the summer sky hovering around the galactic center, a few stragglers reside off the beaten path. One such cluster is M15, located near the nose of the autumn constellation Pegasus the Winged Horse.

M15 was first spotted in 1746 by Jean-Dominique Maraldi, who described it as "a quite bright, nebulous star, which is composed of many stars." Charles Messier rediscovered it 18 years later, but because his telescope couldn't resolve the cluster, he described it as a "nebula without star."

Binoculars reveal M15 as a small, misty glow accented by a brighter core about 4° northwest of Enif (Epsilon [ε] Pegasi). A 4-inch telescope can resolve some of the stars around the fringe of this globular. For the best views, try a moderate- to high-power eyepiece greater than 100x, if seeing conditions permit.

M15, located some 34,000 light-years from Earth, crams more than 100,000 stars into a space about 175 light-years across. Nestled among those stars are some unusual suspects, too, including eight pulsars, a double neutron star named M15-C, and more than 100 variable stars.

Another unique resident of M15 is the first planetary nebula found in a globular. German astronomer Friedrich Küstner first cataloged this planetary in 1921, although he erroneously listed it as just another cluster star. However, subsequent studies by Francis Pease with the 100-inch (2.5-meter) Hooker reflector at Mount Wilson Observatory revealed that Küstner's star was not a star at all, but instead a planetary nebula. Today, we know it as Pease 1.

To visually spot Pease 1, you'd need at least a 15-inch telescope, 300x or greater, and an OIII filter. Pristinely dark skies are not necessary and it can be seen in an 18-inch scope through suburban light pollution. However, your sky must be exceptionally transparent and steady. — P.H.

DAN CROWSON

CHIRAG UPRETI

77 The Coalsack Nebula ←

The Coalsack Nebula is the most famous naked-eye dark nebula in the entire sky. Located in the Southern Hemisphere next to the Southern Cross (see #3), the shadowy nebulosity looks like a large void (5° by 7°) in the bright, flowing stream of the Milky Way. That's more than large enough to fill most binocular fields.

While the majority of observers see the Coalsack as a uniform black patch, with careful scrutiny, some can detect intricate filamentary details within. For viewers to perceive these subtleties, the night must be free of both moonlight and earthly interference like light pollution and atmospheric dust.

The Coalsack was well known to early cultures. Inca legends tell how the creation god Ataguchu once became so enraged that he kicked the Milky Way, causing a portion of it to fly off and creating the Small Magellanic Cloud. The hole left behind was the Coalsack. Australian Aboriginal lore, meanwhile, refers to it as the head of an emu, even drawing a starless constellation of the lanky bird's body that follows the form of the Milky Way's stream northward.

However, we should refer to the Coalsack as the Dustsack, because that's what it is: a gargantuan cloud of interstellar dust some 600 light-years away, making it the nearest substantial dark nebula to our solar system. Each grain of cosmic dust within is coated with an outer layer of water ice and simple organic molecules such as frozen carbon monoxide. The dust is so dense in regions that it blocks most of the visible light from stars behind the cloud. The bit of starlight that does seep through takes on a reddish tint. This effect, called interstellar reddening, occurs as the dust particles preferentially absorb and scatter blue light.

But like planetary nebulae, the Coalsack won't last very long in cosmic terms. Fast-forward millions of years and this dusty void will have transformed into a display of newly sparkling stellar diamonds. —P.H.

76 M65 and M66 ↓

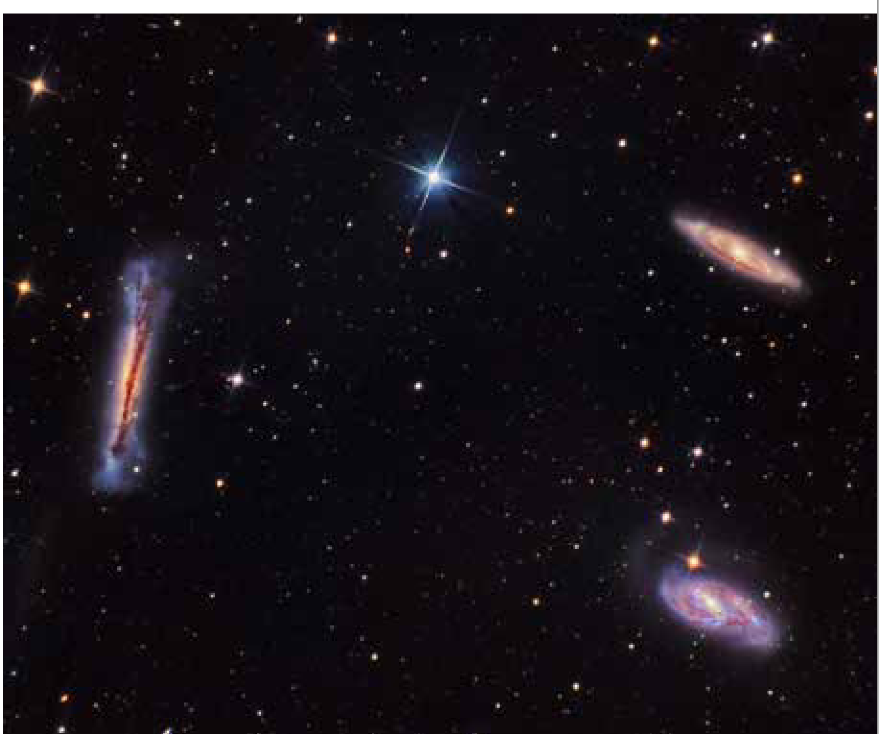
A twin treat, M65 (top right) and M66 (bottom right) in Leo are arguably the most dynamic galaxy pair in the northern night sky, next to M81 and M82 in Ursa Major. Under a dark sky, binoculars will show them as two roughly magnitude 9 glows 20' apart. Together with the dimmer edge-on spiral galaxy NGC 3628 (35' to the northeast), they form the famed Leo Triplet of galaxies. All lie about 35 million light-years distant, in the Leo Spur — a little gathering of galaxies between the Local Group and Virgo Cluster. We see all three galaxies presented at different viewing angles, allowing us to inspect their spiral structure from different perspectives.

Charles Messier discovered both M65 and M66 in 1780, midway between Theta (θ) and Iota (ι) Leonis, noting they were "in the same field of view."

In 1848, William Parsons, Earl of Rosse, resolved M65 into a "spiral or annular arrangement." He later noticed dark lanes on either side of the nucleus. Indeed, the inclination of M65 is nearly optimal to show the galaxy's dust silhouette, which traces a well-defined spiral pattern with two main arms. At its center lies a diffuse nucleus and bar embedded in a tiny central bulge. Through a moderate-sized telescope at 70x, its spiral structure requires attention — though the pattern appears coiled north of the nucleus, the southern disk region requires larger apertures to resolve.

M66, on the other hand, is a Milky Way-sized barred galaxy that sports prodigious dust, a displaced core, and grand spiral arms. One of these arms is "hooked," thanks to distortions suffered in a gravitational war with NGC 3628. A fantastic 400,000-light-year-long tidal tail has also been detected between these two galaxies, the result of an encounter a billion years ago.

Through a telescope at moderate magnifications, M65 appears oval-shaped and quite large compared to M66, which is a much more difficult object to study. M66's bright nuclear region stands out the most, with extensions that form the "trunk" of its S-shaped spiral structure, which large telescopes will show as soft strips of dappled light. —S.J.O.



JARED BOWENS

78 M74 →

A phantom among the bright galaxies, M74 is one of the closest and largest face-on spirals in the sky — yet it is difficult to observe, especially from light-polluted areas. Under a dark sky, the galaxy is a wonder. Just 32 million light-years away in Pisces, this grand-design spiral of 100 billion stars sports perfectly symmetrical spiral arms unwinding from a blazing core.

The galaxy's entire disk, tilted only 5° away from face-on, has undergone active star formation within the past 500 million years. By contrast, its inner regions have a dearth of young stellar specimens — an example of how galaxies regulate star formation over time. Thick dust lanes also join the arms out to a quarter of a revolution before they begin to thin.

Pierre Méchain discovered M74 in 1780 and wrote to Charles Messier: "It is quite broad, very dim, and extremely difficult to observe." Indeed, to this day, M74 has proven to be the most troublesome and elusive object in Messier's catalog. The problem is that the galaxy's large apparent size (11') and low surface brightness (14.4 magnitudes per square arcsecond), requires a very dark sky to be seen. If the skies are dark enough, however, skilled observers can pick out the galaxy using humble binoculars.

M74 lies about 1¼° east-northeast of Eta (η)

GERALD RHEMANN

SERGEY TRUDOLYUBOV

Piscium. A 4-inch telescope at low power will show it as a ghostly globe of uniform light surrounding a bright, starlike nucleus. Moderate magnifications give more definition to the central region. Higher powers show a stellar dappling to the disk, which led John Herschel to mistake this object for a globular star cluster partially resolved. In 1861, Lord Rosse "felt confident it was a spiral." Not until 1893, however, did Welsh astronomer Isaac Roberts finally image it as a "perfect and beautiful spiral."

With patience, a moderate-sized telescope can bring out the spiral structure. Even then, the arms are like phantoms, materializing and fading from view. Larger telescopes will show them well. — S.J.O.

79 The Lagoon Nebula ↑

The Orion Nebula (see #19) gets some stiff competition for best in class from the Lagoon Nebula (M8) in Sagittarius. The Lagoon Nebula is visible to the naked eye on dark moonless nights as a bright patch along the Milky Way due north of the spout of the Sagittarius Teapot asterism.

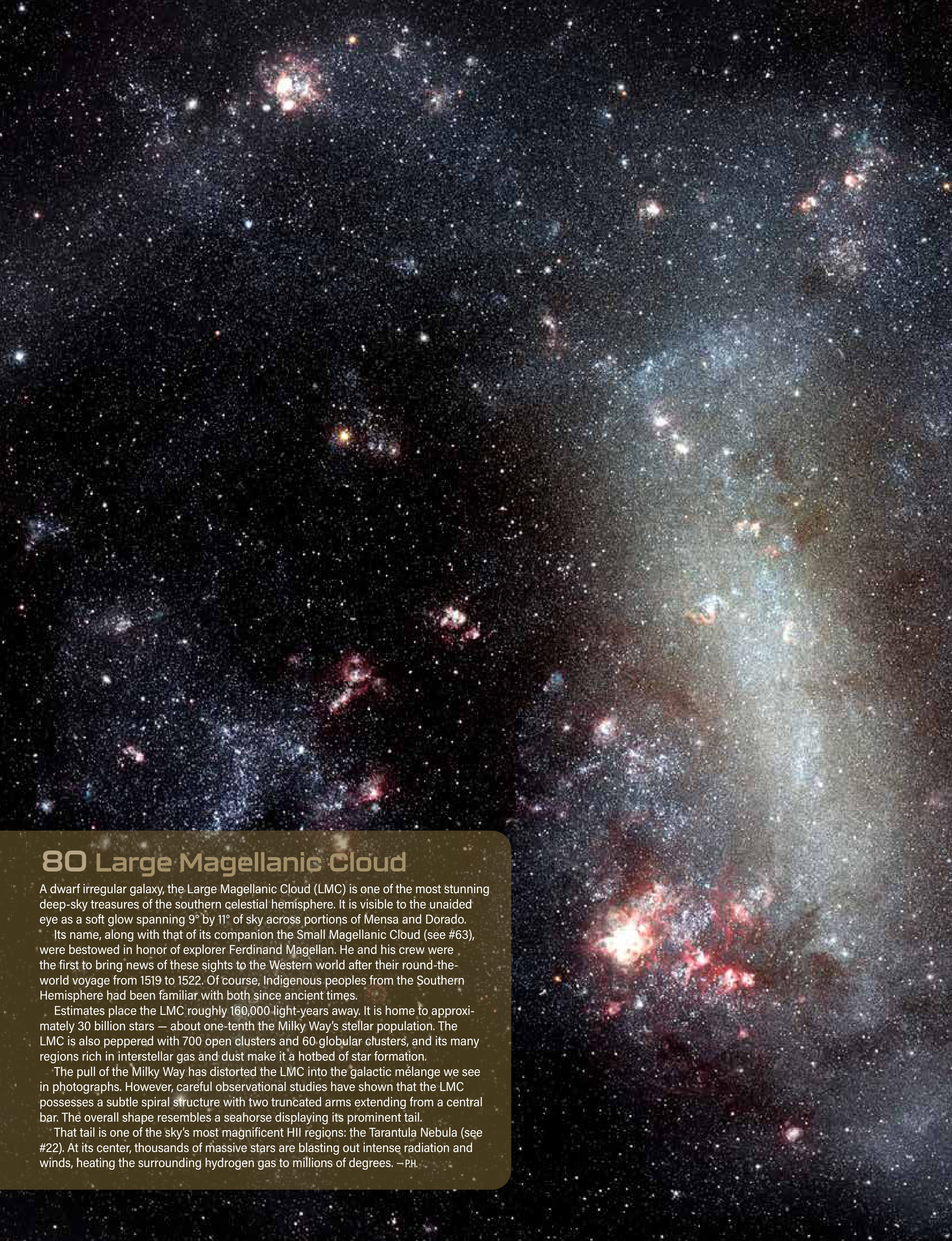
The Lagoon Nebula was discovered by Italian astronomer Giovanni Battista Hodierna in 1654, when he described it as a *nebulosa*. What Hodierna likely saw, however, is not what we know today as the Lagoon Nebula, but rather an embedded open star cluster cataloged separately as NGC 6523. In fact, most records of the early observations refer to the open cluster without mentioning the nebula from which it was born.

William Herschel was the first to define the nebula as a separate object. In 1785, he described it as "an extensive milky nebulosity divided into two parts." Irish astronomer Agnes M. Clerke coined the nickname "the Lagoon Nebula" in her 1890 book *The System of the Stars*.

When we set our sights on M8, our gaze is taking us some 4,100 light-years away. Under dark skies, 10x50 binoculars can distinguish the Lagoon's overall oval shape, as well as the dark slice that cuts the nebula in half. Telescopes, meanwhile, reveal several of the swirling nebula's more complex features.

Hidden within the nebula is another star cluster: NGC 6530. Some of its young stars sparkle among the rifts of nebulosity. If you plan to seek it out, expect to spot between two dozen and three dozen luminaries through most backyard scopes.

Many other stars lie within the Lagoon's clouds, too. One of the brightest is 6th-magnitude 9 Sagittarii, a massive binary system comprising two extremely close type O stars whose radiation energizes much of the nebula. Another noteworthy star in the field is Herschel 36, a magnitude 9.5 supergiant just west of the brightest portion of the nebula. — P.H.



80 Large Magellanic Cloud

A dwarf irregular galaxy, the Large Magellanic Cloud (LMC) is one of the most stunning deep-sky treasures of the southern celestial hemisphere. It is visible to the unaided eye as a soft glow spanning 9° by 11° of sky across portions of Mensa and Dorado.

Its name, along with that of its companion the Small Magellanic Cloud (see #63), were bestowed in honor of explorer Ferdinand Magellan. He and his crew were the first to bring news of these sights to the Western world after their round-the-world voyage from 1519 to 1522. Of course, Indigenous peoples from the Southern Hemisphere had been familiar with both since ancient times.

Estimates place the LMC roughly 160,000 light-years away. It is home to approximately 30 billion stars — about one-tenth the Milky Way's stellar population. The LMC is also peppered with 700 open clusters and 60 globular clusters, and its many regions rich in interstellar gas and dust make it a hotbed of star formation.

The pull of the Milky Way has distorted the LMC into the galactic mélange we see in photographs. However, careful observational studies have shown that the LMC possesses a subtle spiral structure with two truncated arms extending from a central bar. The overall shape resembles a seahorse displaying its prominent tail.

That tail is one of the sky's most magnificent HII regions: the Tarantula Nebula (see #22). At its center, thousands of massive stars are blasting out intense radiation and winds, heating the surrounding hydrogen gas to millions of degrees. —P.H.

FERNANDO OLIVEIRA DE MENEZES

KFIR SIMON

81 NGC 253 ↑

The Silver Dollar or Sculptor Galaxy is the brightest deep-sky object in the diminutive constellation Sculptor. NGC 253 is highly inclined at 78° from face-on, and doesn't have distinct arms across its broad, 27.5' by 6.8' disk. Recent imaging shows a poorly developed bar and two concentrated arms amidst a disk rich in dark and emission nebulae.

At 8th magnitude, NGC 253 can be seen in binoculars and is about 7° south of Beta (β) Ceti. Slightly larger optics may allow you to note the small nuclear brightening, and even larger apertures will reveal some granulation from the abundance of dust clouds. Without distinctive arms, the mottled disk is worthy of scrutiny.

NGC 253 is located 11 million light-years from us and is the largest in the Sculptor Galaxy Group, one of the closest galaxy groups to ours. It is so close that other members are scattered in other constellations, including NGC 247 in Cetus and NGC 625 in Phoenix. This group is dominated by low-mass irregular galaxies similar to the Large and Small Magellanic Clouds; its members are best seen in large optics because they range from 10th to 16th magnitude.

The Silver Dollar Galaxy is about as far from the plane of the Milky Way as possible, located around 2° from the South Galactic Pole. That means we are looking through a minimum amount of interstellar dust. The nearest bright deep-sky object (1.8° southeast) is the magnitude 8 globular cluster NGC 288. It's worth noting that although most globulars are close to the Milky Way's galactic plane, at 37' northeast of the South Galactic Pole, NGC 288 is about as far as a globular cluster can get in apparent position (but not physical distance) from the plane. —A.G.

82 M55 →

M55 is one of the most unsung yet beautiful globular star clusters in the night sky. It's also one of the most southerly globulars in Charles Messier's catalog. Abbe Nicolas Louis de Lacaille discovered it in 1751 while surveying the southern stars from the Cape of Good Hope. Through his small telescope (inferior to today's binoculars) he recorded it as looking like the "faint nucleus of a large comet." Messier's report of it was not much different: "a whitish patch about 6' across."

Today we know this close (about 17,600 light-years distant) and ancient (roughly 12.5 billion years old) relic bristles with up to perhaps 100,000 suns spread loosely across 100 light-years of space. This senior swarm of gravitationally bound starlight is approaching us at more than 100 miles per second (62 kilometers per second) on an elliptical orbit that arcs through the distant halo of our galaxy.

While all globular clusters are richly populated with metal-poor aged stars, M55 is exceptional in this regard: On average, its stars have only about 1 percent of the fraction of heavy metals found in our Sun, making M55 one of the most metal-poor globular star clusters known. It also has a possible tidal extension — not visible to amateur equipment — which could be caused by the tidal shocks that buffet the cluster when its orbit takes it swooping through the disk of the Milky Way.

Under dark skies (which are required to see this cluster well), keen-eyed observers have spied its 6th-magnitude glow without optical aid about 8° east-southeast of Zeta (ζ) Sagittarii. Binoculars will present the cluster well, as a uniformly hairy star. The telescopic view becomes increasingly more magnificent as power is added. At low power, the cluster's uniform glow splinters into teasing whispers of structure.

DAN CROWSON

The cluster begins to blossom at 70x when some of its brighter members (11th magnitude) pulse in and out of view across the globular's 20'-wide face. Higher magnifications bring out more stars. Those in M55 on the horizontal branch — the stage of stellar life that red giants evolve into — shine at an average magnitude of 14.4, meaning that moderate-sized telescopes can resolve the cluster reasonably well. —S.J.O.

DAN CROWSON

83 M22 →

In 1665, while observing Saturn (which was located in Sagittarius at the time), German astronomer Johann Abraham Ihle came upon an unexpected sight. Just over 2° northeast of 3rd-magnitude Kaus Borealis (Lambda [λ] Sagittarii) at the top of the Teapot asterism, he found a small, nebulous patch. Although he had no idea what he had seen, Ihle had unintentionally discovered the first globular cluster. Today, we know it as M22.

The Hercules Cluster (M13; see #69) may be considered one of the finest globular clusters in the night sky, but it gets stiff competition from M22, which appears larger and a half-magnitude brighter than its Herculean counterpart. That apparent superiority, however, is an illusion caused by disparate distances. M22 is little more than 10,000 light-years away — less than half the distance to M13.

Despite M22 containing less than half the stars of M13, it still proves easier to resolve. A 3.5-inch scope is all it takes to spot at least some stars around the fringes. An 8-inch is more than enough to display a multitude of faint stars strewn across the entire cluster.

Make a slow, careful study of M22, noting its overall shape. Most globular clusters are round, but not M22. It's elliptical, with the long dimension angled northeast-southwest. This odd shape is apparent through nearly all scopes and even in larger binoculars.

Of the 150 known globular clusters associated with the Milky Way, M22 is one of only four that contains a planetary nebula. In 1985, NASA's Infrared Astronomical Satellite uncovered a mysterious infrared source among the cluster's stars. After four years of research, astronomers showed that the source was a planetary nebula located 1' south of the cluster's center.

Finding this planetary, known as GJJC 1, takes an aperture of at least 20 inches. The best seeing conditions are also a must, because at least 600x is required to make out the planetary's tiny disk. — P.H.

DON GOLDMAN

84 Seyfert's Sextet ↑

Located in Serpens Caput, a constellation with few deep-sky objects, Seyfert's Sextet was one of the first compact galaxy groups ever noted. That occurred in 1948, when astronomer Carl Seyfert discovered that the previously cataloged NGC 6027 was actually more than one object. His Sextet became the densest group of galaxies known at the time.

Seyfert's initial observation described six galaxies close together, but that isn't the case. Later observations revealed only four interacting galaxies (NGC 6027 and NGC 6027a, b, and c) at a distance of 190 million light-years. A fifth galaxy, NGC 6027d, is actually 410 million light-years behind the group. And the sixth galaxy isn't a galaxy at all — it's a plume of stars generated by interactions between NGC 6027 and NGC 6027a. The galaxies have diameters that range from 0.9' to 0.2'.

The four physically associated members are galactic Lilliputians. Astronomers believe the entire group would fit inside the width of the Milky Way, some 100,000 light-years. Three share a common halo that in most galactic collisions would generate new star formation, but not here. Perhaps this means that within the next several billion years, the galaxies might merge and form a large elliptical galaxy.

Edouard Stephan discovered NGC 6027 in 1882, but didn't resolve the others. This highly inclined barred lenticular galaxy is the group's brightest member at magnitude 14.7. NGC 6027a is magnitude 14.9. Perhaps the dark lane of this Sa peculiar spiral dims it a little. It's a tiny version of the Sombrero Galaxy (M104; see #29). NGC 6027b is similar in size and nature to NGC 6027 but is a more challenging magnitude 15.3. NGC 6027c is by far the group's faintest member at magnitude 16.7. It's a highly inclined SBc or SBd galaxy. Hubble photos show it is rich in young blue stars but poor in HII regions. Beyond the true group, NGC 6027d is a giant face-on barred spiral more than 800 million light-years away. At magnitude 16.5, it's a challenge.

Observing Seyfert's Sextet requires a large telescope. You might glimpse it in a 13-inch telescope under excellent skies, but resolving members requires more aperture, magnification, and a very steady atmosphere. — A.G.

85 The Trifid Nebula ↓

The Trifid Nebula (M20) is the trifecta of deep-sky objects: It combines a blue reflection nebula with an emission nebula glowing in red Hydrogen-alpha (Hα) light, all divvied up by opaque lanes of dark nebulosity threaded throughout.

For all its spectacle in photos, however, the Trifid Nebula is visually faint. That explains why, when Charles Messier discovered it June 5, 1764, he portrayed this 20th entry in his catalog as only a "cluster of stars." William Herschel was the first to describe the object as "three nebulae, faintly joined, form a triangle. In the middle is a double star." It was this appearance that led Herschel's son John to later christen the object Trifid, from the Latin *trifidus*, meaning split into three.

A quick glance at M20 through a scope will usually show only a 7th-magnitude star surrounded by a faint glow. With careful observation, that glow will appear cleaved by dark nebulae. The dark lanes all seem to diverge away from the central star, HD 164492.

The energy irradiating the Trifid, which is roughly 5,000 light-years from Earth and spans some 15 light-years, comes from a young star cluster buried within it. HD 164492 is the brightest member of this cluster. High magnification reveals HD 164492 is a multiple star system, too. How many stars can you resolve? There is a magnitude 8.7 star 11" to the primary star's south and a 10th-magnitude component 6" to its north. The former is also joined by two close-set stars, and one more hidden in the system makes this a sextuple star system.

Since the Trifid never gets very high in the sky from mid-northern latitudes, for the best view, you will need a clear southern horizon free from interfering light pollution. Averted vision will certainly help, as will using a narrowband filter. With a double-digit aperture, the full shape of the Trifid blossoms into view. More than two dozen stars appear sprinkled across the partitioned emission nebula. Faint tufts of the reflection nebula extend farther to the north, toward and beyond 7th-magnitude HD 164514. — P.H.

JOHN CHUMACK

MAICON LOPES NUNES

86 The Hyades ↑

Crisp winter nights bring us a glorious naked-eye treasure: the Hyades. This V-shaped gathering of suns has been recognized as a celestial bull since at least 4000 B.C., when the Sun resided among its stars during the spring equinox — a hopeful union that heralded the return of life and agricultural activity to Earth after a barren winter. Classically, the Hyades represented the mythical seven daughters of Atlas, half-sisters of the Pleiades; together they formed the 14 Atlantides.

To modern astronomers, however, the Hyades mark the bright core of the Taurus Moving Cluster, which, at a distance of 150 light-years, is the closest star cluster to our Sun.

Formed about 625 million years ago, the Hyades appears to share a common origin with the Beehive Cluster (see #94) — their ages and motions through space are remarkably similar. The Taurus Moving Cluster is now rifling through space at 29 miles per second (46 kilometers per second), toward a point a few degrees east of Betelgeuse. It passed closest to our solar system more than a million years ago, and in 50 million years it will appear only about ½°-wide through our telescopes.

Fortunately, today we can revel in the cluster's majesty, as the central Hyades stars span about 5.5°, or about 15 light-years. Adding to its splendor is the warm light of the orange giant star Aldebaran, at the tip of the V's southeast branch; however, it is not a part of the Hyades proper. ESA's Hipparcos satellite has confirmed that Aldebaran is a foreground object 65 light-years distant, while the center of mass of the Taurus cluster lies 151 light-years from Earth.

The smallest of binoculars will transform the celestial V into a stunning starscape about 10 light-years across. The outlying regions cover at least twice that distance. But do run your binoculars over the face of the Bull, as there are ample stellar pairings that make the sight feel "homey." Most notable are the two Theta stars (θ^1 and θ^2 Tauri), which shine at 4th and 3rd magnitude, respectively, and are separated by about 6'. The Sigma stars (σ^1 and σ^2 Tauri) are even more appealing, appearing as two chalk-white beacons of near-equal intensity (magnitude 5) separated by 7'. — S.J.O.

87 M100 ↓

Just 2° northeast of 6th-magnitude 6 Comae Berenices is 9th-magnitude M100. Located some 55 million light-years distant, it is the Virgo Cluster's brightest spiral galaxy. The galaxy was another find in 1781 by French comet hunter Pierre Méchain, who notified his comet companion Charles Messier. Like M98 and M99, Messier found it difficult to detect, possible "only under great conditions, and near meridian passage."

One can only imagine their reaction had they lived today to see this face-on spiral galaxy — comprised of some 400 billion suns spread across 100,000 light-years of space — in all its glory. M100 is a grand-design spiral and, like M51 (see #56), displays two prominent, well-defined spiral arms (and several fainter ones) that uncoil from the ends of a central bar like a whirligig.

Infrared images show the galaxy's arms sweeping out from a prominent ring of hot, bright dust (an area of intense star formation) that surrounds the inner galactic core. Episodes of starburst activity have been occurring in this ring for the past 500 million years. The arms show a slight asymmetry (being brighter toward the south) and gradually become cooler as they recede from the core.

M100 is a challenging object to observe through a small telescope, mainly because its light is spread across 6' of sky — almost twice the extent of the Owl Nebula (see #38), which is a full magnitude brighter! Even using high magnification, look for a pale orb with a soft core and no central starlike nucleus. Spend some time behind the eyepiece, though, and sweep your eye across the galaxy's face to see if you can pick up hints of spiral enhancement. Supernova hunters should be aware that M100 has produced seven supernovae between 1901 and 2020. —S.J.O.

MADHUP RATHI

DAN CROWSON

88 M35 ↑

One of winter's finest open clusters, M35 is tucked inside the southwestern corner of Gemini the Twins. It was first found in either 1745 or 1746 by Swiss astronomer Philippe Loys de Chéseaux, although his observations were never widely circulated. English astronomer John Bevis bumped into it a few years later. Bevis' published discovery led Charles Messier to observe the object in August 1764, after which he added it as the 35th entry in his catalog. He recalled the view of M35 as a "cluster of very small stars, near the left foot of Castor."

Specifically, M35 is located a little more than 2° northwest of Propus (Eta [η] Geminorum). It looks as if Castor is about to kick M35 right through the horns of Taurus the Bull. Perhaps astronomers should nickname it the Soccer Ball Cluster. Goal!

Shining at 5th magnitude, you can glimpse M35 with naked eyes, given pristine sky conditions. But even without a great sky, the open cluster is easily seen through binoculars. Some 10x50s will resolve about eight or nine points of light across the misty glow of other, unresolved cluster stars.

If you aim a telescope its way, M35 explodes into stardust, with dozens of dazzling suns strewn across a field some 28' wide. That means that low power paired with wide-field eyepieces will deliver the most satisfying results.

All told, M35 claims more than 400 stellar members. Most of those are white or blue-white main sequence stars that are still fusing hydrogen into helium in their cores. You may also notice a few stars tinted with subtle shades of yellow or orange. Those have evolved off the main sequence and are no longer producing energy through hydrogen fusion in their cores.

A second rich open cluster known as NGC 2158 lies about 0.5° southwest of M35. Messier did not document this one, but it is bright enough to be visible as a vague glow through a 4-inch scope. Though they appear next to each other in the sky, M35 is about 2,800 light-years away, while NGC 2158 is about 10,000 light-years beyond it. —P.H.

89 M77 →

The prototypical Seyfert galaxy M77 in Cetus is the brightest (magnitude 9) and closest (about 45 million light-years) of its class. Seyfert galaxies are named after American astronomer Carl Seyfert, who in 1943 created a list of galaxies that all have an exceptionally bright or starlike nucleus. Seyferts have a spectrum dominated by prominent emission lines, which originate from interstellar gas being heated near the galaxy's nucleus by a supermassive black hole.

In 2018, the Atacama Large Millimeter/submillimeter Array (ALMA) in Chile imaged a 20-light-year-wide doughnut-shaped ring (or torus) of dust and gas rotating around M77's central black hole, which contains the mass of 15 million Suns. The torus appears slightly asymmetric, and its rotation exhibits highly random motion. This suggests the active galactic nucleus had a violent history, possibly including a merger with a smaller galaxy.

Pierre Méchain discovered M77 on Oct. 29, 1780, and reported its position to Charles Messier. Messier saw it as a "cluster of faint stars" with nebulosity, and William Parsons, Earl of Rosse, called it a "blue" spiral nebula in 1848. Today we know M77 is a chaotic spiral galaxy with an infrared bar. Its bright inner disk rivals the Milky Way in size, and the galaxy also sports a fainter spiral skirt that increases M77's size to 170,000 light-years.

You'll find this 9th-magnitude wonder 1° southeast of 4th-magnitude Delta (δ) Ceti, just west of a 10th-magnitude star (SAO 130073). The galaxy's youthful inner region (consisting of tightly wrapped, knotty spirals near the nucleus with two main dust arms) can be viewed through moderate-sized telescopes at 150x and greater. Its older, fainter outer region requires larger telescopes. Astroimagers can capture its prominent star-forming regions located near the boundary of the inner and outer regions.

The galaxy's brightest star-forming regions have been spied in telescopes as small as 4 inches; this view probably led astronomers like Messier to mistake it as a cluster. —S.J.O.

DAN CROWSON

DOUGLAS J. STRUBLE

90 Crab Nebula

Have you ever started something that lasted a lifetime? Charles Messier found a whitish smudge near Zeta (ζ) Tauri on Aug. 28, 1758, while following a comet he had discovered two weeks earlier. But this smudge didn't look like any comet he had ever observed, so he noted its location on a chart. And thus, without fanfare, the French observer began his catalog of non-cometary objects.

But Messier was not the first to observe M1 (also cataloged as NGC 1952). John Bevis is credited with first observing this supernova remnant in 1731. William Parsons, Earl of Rosse, named the Crab Nebula based on his interpretation of the shape from his observation in 1842. It isn't the first deep-sky object whose name might be considered questionable.

In 1928, Edwin Hubble proposed a connection between the Crab Nebula and reports of a bright star that had appeared in Taurus in A.D. 1054. That supernova — estimated to have popped off 6,500 light-years away — was bright enough to see during the day for three weeks and remained in the night sky for two years. Observations by Korean, Japanese, Chinese, and Arab observers recorded a star brighter than Venus. Astronomers now estimate the star blazed between magnitude –4 and –7.

The Crab Nebula is a source of energy across the electromagnetic spectrum. Known as Taurus A, it's the brightest radio source in that constellation. Its central rapidly rotating neutron star — called a pulsar, the remnant of the star that exploded — is the most persistent and brightest gamma-ray source in the heavens. Don't worry, though — observing it won't damage your eyes. Our atmosphere absorbs the radiation.

While the nebula is magnitude 8.4, its pulsar is magnitude 16.2 — bright enough for today's larger telescopes to pick up. A chart is essential for distinguishing it from other faint stars scattered in front of the nebula.

A generous 6' by 4' across, M1 is expanding at 0.5 percent the speed of light. It can be seen in binoculars or a spotting scope under dark skies, and is bright enough to see in suburban skies, especially with a filter. It's a fun object to show your friends or guests at a star party as you explain the nebula's history. —A.G.

TERRY HANCOCK

91 M41 →

JOHN CHUMACK

The dazzling 4.5-magnitude open star cluster M41 dangles in Canis Major some 4° south of Sirius, the brightest star in the night sky. From a dark site, the cluster shines to the unaided eyes as a misty glow, like a metal tag on the collar of the celestial Dog.

M41 may have been identified by Aristotle, who described a star with a tail in the Dog — not surprising coming from a man who took a shining interest in comets. Today, the cluster appears to unaided eyes exactly as he described: a circular form with a dim extension to the north.

The cluster lies about 2,300 light-years distant and is 240 million years old. There is little intervening dust to affect its appearance, so its 100-odd stars shine with uncommon purity. At least three of them are 7th magnitude and should be within range for sharp-eyed, naked-eye observers. Handheld binoculars will resolve about a dozen members. Roughly 50 of its stars shine between 7th and 13th magnitude, putting them within reach of small- to moderate-sized telescopes.

M41's stars will fill a telescopic field of view 30 percent larger than the Full Moon. Look for a striking reddish star at the heart of the sprawling cluster, with streams of irregularly bright suns curling outward. The view is best at low power. Larger-aperture telescopes will reveal the presence of many red (or orange) giant stars; the hottest star is of spectral type A. Up to 80 percent of its stars may be binaries. While we cannot see most of these, many of the cluster's visible stars do form pairings. – S.J.O.

MADHUP RATHI

92 M81 ↑

M81 is one of the spiral wonders of the night sky. It joins neighboring galaxy M82 (see #70) to make one of the most dynamic pairings of galaxies in the high northern heavens. At 12 million light-years distant, M81 is a primary member of the M81 Group of galaxies — one of the nearest groups of galaxies to our own Local Group. It is also one of the most distant objects in the universe accessible without optical aid.

German astronomer Johann Elert Bode discovered this "nebulous patch" Dec. 31, 1774, calling it "more or less round, with a dense nucleus in the middle." Most observers following him hailed the brightness of the galaxy's nucleus, including Isaac Roberts, who photographed it and described it as a "spiral with a nucleus." Indeed, M81 was the first known spiral galaxy to reveal evidence of rotation.

M81 is similar to the Milky Way, resembling a grand-design spiral with two arms. But these arms consist of spiral fragments that branch into many secondary filaments. The arms also host a population of stars formed in an episode of star formation that started about 600 million years ago. This is evidence that M81 may be undergoing a surge of star formation along the spiral arms due to a close encounter with M82; the pair reached their closest points about 300 million years ago.

To find M81, look about 2° east of 24 Ursae Majoris. If you live under a dark sky, use binoculars first to locate the wonder, which will be paired with M82 just 38' away. The telescopic view is splendid: A vast oblique glow, about the apparent size of the Full Moon, shines forth with a pale-yellow light punctuated by a vivid stellar-like nucleus. Two 11th-magnitude stars burn just south of the core and can easily be mistaken for supernovae. Ironically, in 1993, a supernova in M81 blazed to prominence just west of these stars. At magnifications of 70–150x, the galaxy core transforms into a misty spring of light caressed by dark vapors. Delicate wisps of spiral arms surround the core, and together they look like a still photograph of the grandest rotating lawn sprinkler in the cosmos. – S.J.O.

93 The Eagle Nebula ↑

Soaring through the summer Milky Way is one of the most recognizable nebulae in the entire sky: the Eagle Nebula. When photographed in full, this glowing red cloud of ionized hydrogen mixed with billowing clouds of opaque cosmic dust reminds many of a majestic bird in flight, with a wingspan extending across 21'.

The Eagle hatched from a star that exploded some 5.5 million years ago. Since then, it has evolved into a productive region of star formation, giving birth to more than 8,000 new stars, according to some estimates.

Many references identify the entire Eagle Nebula as M16 in Charles Messier's catalog, but that is incorrect. In Messier's own words, his 16th entry is described as a "cluster of small stars, mingled with a faint glow." He actually did not see the nebula surrounding the stars, but only the diffuse glow of unresolved stars within the cluster.

Messier's description of the Eagle mirrors the experience most get using today's unfiltered backyard telescopes. A 3-inch scope will show some two dozen suns surrounded by a foggy backdrop of fainter, unresolved cluster stars. But add on a narrowband nebula filter and suddenly the Eagle begins to spread its wings. The brightest portions of the nebula surround the cluster, as well as extend to its south.

Bumping up to a telescope with an aperture of 10 inches also increases the size and improves the shape of the Eagle. From a dark-sky site, the cloud's shape becomes even more reminiscent of its nickname. The brightest portion, adorned with several dozen cluster stars, forms the eagle's hook-shaped head facing northwest. Fainter portions to the south form its body and extended wings.

The Eagle Nebula gained true stardom in 1995, when the Space Telescope Science Institute released a Hubble image named the Pillars of Creation. That iconic image, one of the orbiting observatory's most famous, shows three elephant trunks composed of cold molecular hydrogen and dust reaching outward from the Eagle Nebula. Ultraviolet radiation from nearby hot stars is gradually eroding the towering columns. As the pillars slowly erode, small globules of even denser gas and dust are revealed. These are known as evaporating gaseous globules, or EGGs. Eventually, most of these EGGs will go on to hatch into mature stars. – P.H.

94 The Beehive Cluster

M44 is one of the heavens' largest, brightest, and nearest open star clusters — a wonder accessible to stargazers of all skill levels. This attractive swarm of stars is visible to the unaided eye as a nebulous patch spread across 1° of sky, appearing like the elongated head of a comet passing through the heart of Cancer the Crab. Known throughout antiquity, 3rd-magnitude M44 outshines all the stars of Cancer by a full magnitude, making Cancer the only constellation in which a deep-sky object is more conspicuous than the constellation itself.

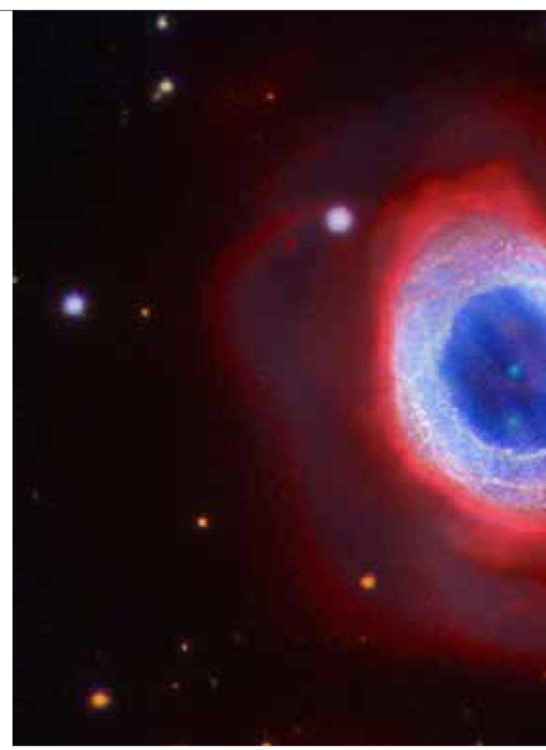
Ptolemy wrote that this mystifying mist was the "center of the cloud-shaped convolutions in the breast [of the Crab], called Praesepe." One of the earliest monikers for the cluster, *Praesepe* is derived from the Latin word *presepio*, which means "manger," referring to the straw-filled manger of the infant Christ. If M44 represents the straw, it is guarded by the two *aselli* (Latin for "donkeys") — the 5th-magnitude Gamma (γ) and 4th-magnitude Delta (δ) Cancri.

Galileo first resolved M44 into a mass of 40 stars with his primitive telescope — a view similar to that through today's handheld binoculars. But the grouping's more popular name, the Beehive Cluster, comes to us from the English observer John Herschel, who, in his 1833 *Treatise on Astronomy*, tells us that the Praesepe resolves into a swarm of stars with an "ordinary night glass." Thus, properly speaking, the Praesepe refers to the naked-eye view, while the Beehive refers to the telescopic view — which, through even the smallest of telescopes, reveals a swarm of nervous starlight.

M44, which is located some 515 light-years away, is a collection of at least 1,000 stars. Most are too dim to see; about 200 range in brightness from 6th to 14th magnitude, 80 of which are brighter than magnitude 10. Keen-eyed observers have resolved several of the brightest stars with their unaided eyes. The 600-million-year-old cluster stretches across 15 light-years of space. —S.J.O.

KASRA KARIMI

95 The Ring Nebula



The Ring Nebula (M57) was first discovered in the winter of 1779. But by whom? Some claim it was French astronomer Antoine Darquier de Pellepoix, while others insist it was Charles Messier. However, most historians now seem to agree it was indeed Messier who found it first.

The Ring Nebula is the sky's most famous example of a planetary nebula. Messier described it as "very dull, but perfectly outlined; as large as Jupiter and looks like a fading planet." This analogy to a planet led William Herschel to coin the term — which, even though it is scientifically inaccurate, we still use today.

Interestingly, while many early telescopic observers referred to objects that we now know are star clusters as "nebulae," they consistently thought the opposite of M57. The Ring Nebula was often misclassified as a star cluster. It was not until 1864, when English astronomer William Huggins conducted pioneering spectroscopic studies of M57, that its true nature came to light.

Appearing as a dim star along the south side of Lyra the Lyre's rectangular frame, the Ring can still be spotted through binoculars and finder scopes. Its famous doughnut shape becomes clear at magnifications between about 100x and 150x. Although the Ring appears smooth and evenly bright through smaller instruments, 8-inch and larger scopes will reveal some bright and dark irregular patches around its surface.

The Ring Nebula resides about 2,000 light-years from Earth and stretches about 1 light-year across. For years, astronomers believed it was cylindrical, with its long axis aimed toward Earth. But we now know it's much more complex. An outer shell of nitrogen appears red in deep images, while an inner shell of hotter oxygen takes on a green hue. The blue interior (due to copious helium) sports a football shape that's projecting outward toward us. And in the center of it all is the white dwarf responsible for the Ring.

ALLAN COOK/ADAM BLOCK/NOAO/AURA/NSF

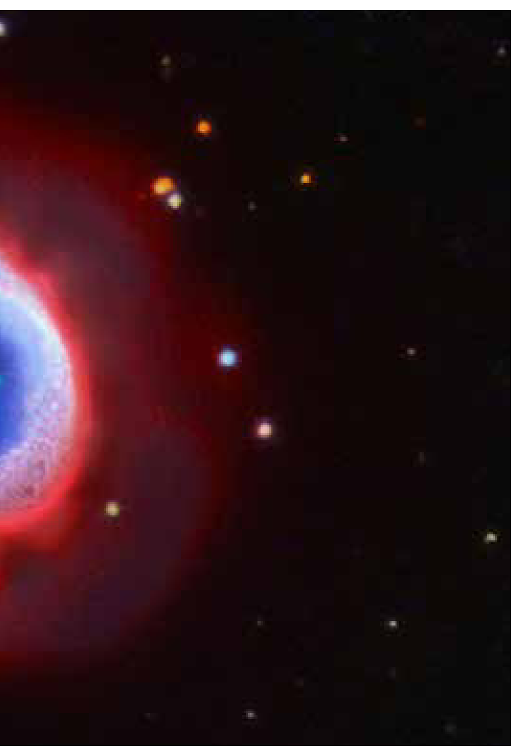
96 M7 ←

Our summer sky is bespangled with hundreds of sparkling open star clusters. One of the finest is M7 in Scorpius. It lies just 5° east-northeast of the Scorpion's stinger stars: Shaula (Lambda [λ] Scorpii) and Lesath (Upsilon [υ] Scorpii). Under dark skies, M7 can be seen by the naked eye as a small patch of light against the glow of the surrounding Milky Way. Depending on where you live, you will need a good view to the south to spot it, since it lies nearly 35° south of the celestial equator. That makes it the southernmost member of the Messier catalog.

Ptolemy must have enjoyed a good view of M7 in A.D. 130 because he subsequently noted the cluster as a cloudy patch in his monumental tome *Almagest*. That's why, even today, M7 is still sometimes referred to as Ptolemy's Cluster. Had Ptolemy had binoculars, however, he would have immediately seen the cloudy patch resolve into a striking array of stars spanning more than 30'. Astronomers estimate the cluster is some 980 light-years away and stretches about 25 light-years across. Between 80 and 100 stars call M7 home, although a plethora of field stars in the surrounding region make the exact number hard to pin down.

Because M7 covers a wide swath of sky, binoculars and wide-field scopes are best for appreciating the object's beauty. More than 30 of its stars are brighter than 10th magnitude and visible in 50mm binoculars. Through 10x50s, the brighter members appear to float in front of a field strewn with fainter points, creating a faux 3D effect. Several of those cluster stars show subtle hues of yellow and blue.

All of M7's stars were born from an interstellar cloud of gas and dust about 200 million years ago. And that same cloud also gave birth to the open cluster M6, found 4° to the northwest. While their stars share a common ancestry, they are, at best, distant relatives, as M6 is half again the distance. — P.H.



DOUGLAS J. STRUBLE

Glimpsing M57's central star, which feebly shines at 15th magnitude, is one of the great observing challenges. Its relative lack of light is further confounded by the brightness of the Ring's central region, which washes it out. Seeing the white dwarf requires a large aperture, transparent skies, and steady seeing. Without all three, it will remain invisible. — P.H.

MADHUP RATHI

97 M46 and NGC 2438 ↑

A treasure within a treasure — that's open cluster M46 and planetary nebula NGC 2438, which lie in Puppis, the Stern of the now-deprecated constellation Argo Navis (the Ship *Argo*).

M46 lies about 15° east of Sirius in the mists of the Milky Way, where it spans about 20' of sky, or about 30 light-years of space. M46 is itself part of a line-of-sight pairing with open cluster M47, a mere 1½° to its west. While M47 appears as a random scattering of disparate suns, M46 presents us with a much more intriguing sight. This 6th-magnitude sphere of uniform light glows like the head of a tailless comet, yet it is anything but.

Charles Messier found M46 on Feb. 19, 1771; he called it a "cluster of very faint stars ... [that] could be seen only with a good telescope." Caroline Herschel, who independently discovered the cluster some two years later, noted that her brother William found it to have "an astonishing number of stars." And indeed it does.

In a telescope, this 250-million-year-old cluster, seen some 5,000 light-years distant, looks more like a loose and finely resolved globular star cluster than an open cluster. While M46 contains some 500 suns, less than 200 of those can be spied reasonably well through most backyard telescopes. The cluster brightens ever so gradually to a somewhat rectangular center with vacancies throughout, especially at high powers.

The most magnificent aspect of the cluster lies hidden among its northern stars: the multi-shelled planetary nebula NGC 2438. While some studies have placed his object 1,000 light-years farther away than M46, the Gaia spacecraft recently revealed the planetary's central star is less than one-third the distance of the cluster. The magnitude 10.8 nebula, which formed only about 4,500 years ago, is surprisingly obvious even through a 3-inch telescope at 150x and greater. While deep images show the planetary with dual shells, which are expanding at 23 miles per second (37 kilometers per second), most backyard telescopes will show it only as a singular 1'-wide annulus of ghostly light. — S.J.O.

DAN CROWSON

98 M61

M61 was a problem for Charles Messier from the start. He first encountered the spiral galaxy May 5, 1779, when he mistook it for a nearby comet whose path he had been tracking. He repeated this error the following night and then again on the 11th before he finally noticed that the "comet" had not moved against the stars.

Once Messier realized his mistake, he noted the "nebula that happens to lie on [the comet's] path and at the same point in the sky," probably confirming to him that these uncataloged objects were but a nuisance to comet hunters. No matter; Italian astronomer Barnabus Oriani had already discovered M61 on the same night Messier first noticed it. Oriani was also following the comet of 1779, but was not fooled. Messier must have chuckled at Oriani's description of the object, as he called it "very pale, looking exactly like the comet."

Today we know M61 as a prominent member of the Virgo Cluster of galaxies — despite its location nearly 10° south of the cluster's heart. We see this nearly 100,000-light-year-long spiral wonder from some 55 million light-years away, giving us a glimpse of what our Milky Way would look like if seen face-on at such a distance. Like the Milky Way, M61 sports a small bar from which an intense inner spiral pseudo-ring displays hefty bursts of star formation, hinting at a lurking, central supermassive black hole.

M61 shines at a respectable magnitude 10 about 5° north and slightly east of Eta (η) Virginis. It lies roughly halfway between the 6th-magnitude stars 16 and 17 Virginis. Be warned: About a dozen NGC galaxies lie nearby, but M61 is the brightest. Its intensely bright core is surrounded by a much fainter disk that swells into view with 70–150x and averted vision. Moderate-sized telescopes may trace out the galaxy's larger spiral structure. Images will reveal its two main luminous arms — one of which bends into two straight sections that meet at a sharp angle — as well as a multitude of fainter arms branching off the main arms. All these features are studded with star-forming regions, several of which appear as mottled patches. An especially large concentration appears near the northern end of the bar. —S.J.O.

99 Veil Nebula

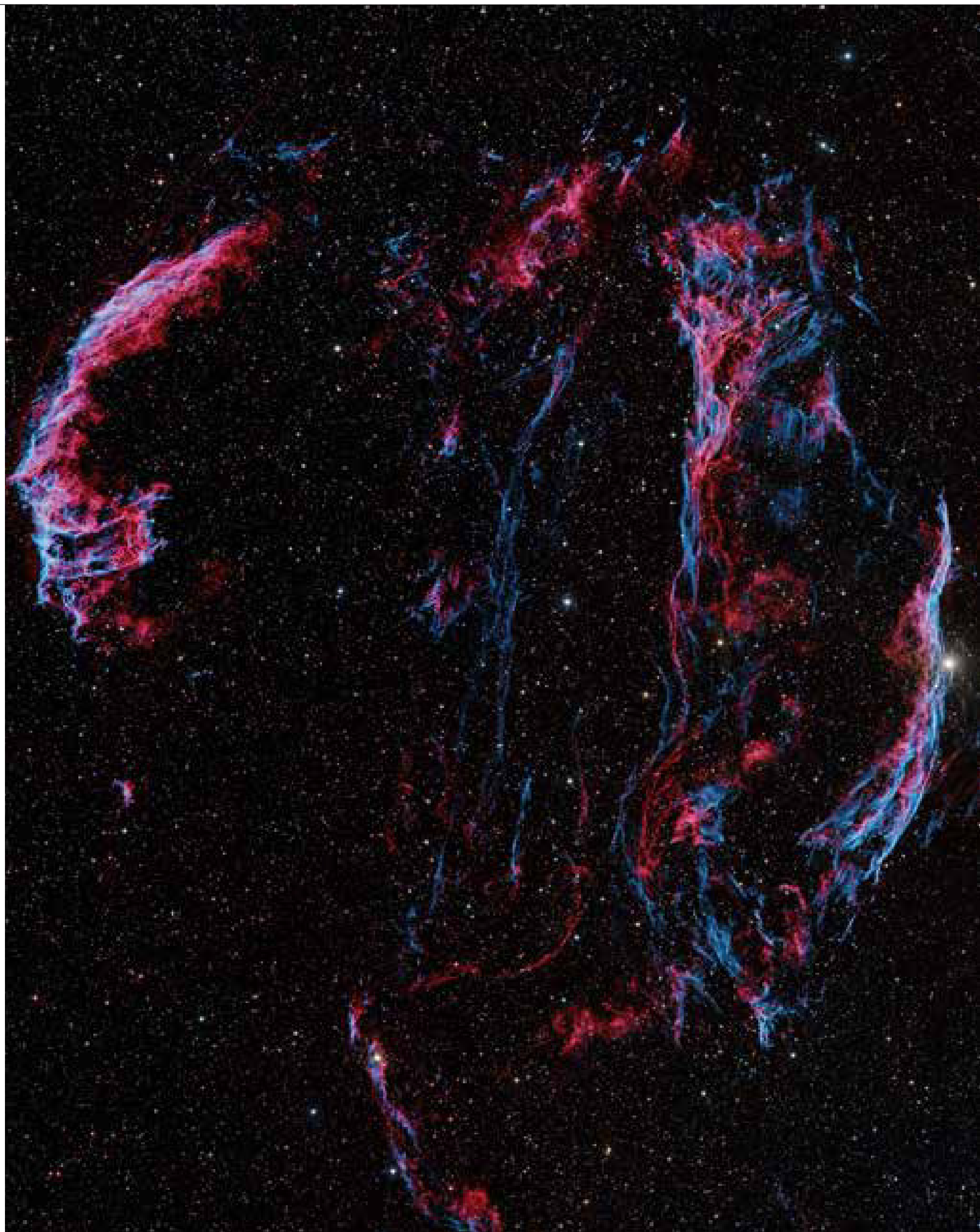
When a massive star dies in a supernova explosion, its gases are ejected in all directions into space. Eventually, the gas may condense and combine with interstellar hydrogen to create new stars. But long before that happens, we can glimpse snapshots of how such explosions change as they age by studying objects at various phases of evolution.

Supernova 1987A in the Large Magellanic Cloud is in the earliest years of such an explosion. In time, a compact expanding region of stellar debris looks something more like the Crab Nebula (M1; see #90). And after a few thousand years of further expansion, the gas becomes tenuous and you get a remnant cloud like the Veil Nebula.

Between 1,410 and 2,100 light-years away (sources disagree), the Veil Nebula and associated Cygnus Loop form one of the closest supernova remnants to the Sun. (Two in Vela and one in Orion are closer.) Its gas has moved outward 65 light-years in every direction since its progenitor — a star about 20 times the Sun's mass — exploded about 10,000 years ago.

William Herschel, the father of deep-sky observing, discovered the Veil Nebula — or, at least, part of it. He first noted NGC 6960, the segment behind 52 Cygni, now called the Western Veil. Since then, astronomers have named and cataloged the other scattered pieces that make up this single large remnant. The Eastern Veil is NGC 6992 and NGC 6995, with an extension designated IC 1340. In between the main arcs in the nebula are three concentrations of brightly glowing gas: Pickering's Triangle (discovered by astronomer Edward Charles Pickering's assistant, Williamina Fleming), NGC 6974, and NGC 6979.

Also called the Cirrus Nebula, the Veil is large (about 3° wide) and bright enough to be seen with binoculars under skies free from light pollution. It looks wonderful in any optics, provided they have either a field wide enough or an aperture large enough to resolve the wispy filaments. An OIII filter really brings out detail and is especially useful when light pollution is an issue. —A.G.



ALISTAIR SYMON

ANTONIO FERRETTI/ATTILIO BRUZZONE

100 The Andromeda Galaxy ↑

What's the farthest object you can see with only your eyes? Unless you live under extremely dark skies unspoiled by light pollution, the answer is the Andromeda Galaxy (M31), located some 2.5 million light-years away. Traveling across such a vast, empty gulf reduces the combined light of M31's estimated 1 trillion stars to a 4th-magnitude smudge that we can spot just 1.5° west of Nu (ν) Andromedae.

The early 20th century was a watershed moment for the Andromeda Galaxy. In 1923, Edwin Hubble calculated the distance to M31 at 1 million light-years. Although later measurements showed this number was off, Hubble's estimate put M31 beyond the known bounds of our galaxy, serving as the first hint that the Milky Way was not the entire universe.

Classified as a barred spiral galaxy like the Milky Way, backyard telescopes display Andromeda as a large, oval smudge of grayish light. Spanning 3°, or six Full Moons placed side by side, Andromeda will engulf your field of view. Take your time studying it and you will notice a bright starlike core marking the center of its disk.

A 4-inch or larger scope shows that the galaxy's southwestern edge gently fades away, while the northeastern edge abruptly halts. This latter sharp boundary is due to a thin lane of opaque dust along the galaxy's circumference. A second, dimmer outer dust lane, as well as a dim adjacent glow, lies beyond, marking a separate spiral arm grasping out in our direction.

Joining Andromeda are two dwarf elliptical satellite galaxies, M32 and NGC 205. M32 lies less than half a degree south of the heart of M31, while NGC 205 is instead just over half a degree to its northwest. Another distinctive feature in the field is NGC 206, a large stellar association in M31 containing more than 300 spectral type O and B stars. You'll find its soft glow about half a degree southwest of M31's center.

Today, the Andromeda Galaxy may appear relatively dim to the naked eye. But it will eventually get much brighter. In about 5 billion years, it will collide with our Milky Way, ultimately merging into a single giant elliptical galaxy. – P.H.

101 The Coma star cluster ↓

A most glorious deep-sky treasure hides in plain sight in the spring sky — the Coma star cluster (Melotte 111), which Ptolemy cataloged as a "nebula" around A.D. 138. This spangle of seven prominent naked-eye suns (and twice as many that are fainter) form the most prominent part of the constellation Coma Berenices, Berenice's Hair.

Unlike most open star clusters, which hug the Milky Way's spiral arms, we see the Coma Star Cluster only about 5° west of the North Galactic Pole — the point on the celestial sphere's northern half at which our galaxy's axis of rotation is aimed. Shining at magnitude 1.8 and spanning 5° of sky, the Coma star cluster is one of the largest and brightest open star clusters in the sky. At a distance of 288 light-years, it is also one of the nearest. The 400- to 600-million-year-old cluster contains some 270 members ranging from magnitude 5 to 10.5. The cluster's total mass is likely less than 100 solar masses, and its density is about one star per 33 cubic light-years.

Its members form a roughly triangular pattern in the sky that spans 22.5 light-years of space. Through binoculars, more than 100 stars can be seen in this wedge-shaped portion formed by 12, 14, and 17 Comae Berenices. The cluster contains no fully-evolved giant stars.

Ten reasonably bright galaxies are within reach of a 4-inch telescope under a dark sky. They all lie within 2° of the Coma star cluster: NGC 4225, 4251, 4274, 4278, 4283, 4314, 4448, 4494, 4559, and 4565. These all belong to the great Coma Cluster of galaxies (see #11), a turbulent array of thousands of galaxies (mostly ellipticals and lenticulars) more than 300 million light-years distant. It is the nearest massive cluster of galaxies and is scattered across more than 20 million light-years of space.

Once you've finished inspecting the Coma star cluster with binoculars and a telescope, study it with your unaided eyes to see how many dim stars you can detect. The cluster contains nine stars between magnitude 6.0 and 7.4, with separations ranging from 12" to 31". – S.J.O.

ALAN DYER

STATEMENT OF OWNERSHIP, MANAGEMENT, AND CIRCULATION

(Required by 39 USC 3685)

1. Publication title: ASTRONOMY
2. Publication no.: 531-350
3. Filing date: October 1, 2021
4. Issue frequency: Monthly
5. Number of issues published annually: 12
6. Annual subscription price: $58.95
7. Complete mailing address of known office of publication: 21027 Crossroads Circle, Waukesha, WI 53187-1612

Contact Person: Liz Runyon, 262-798-6607

8. Complete mailing address of headquarters or general business office of publisher: 21027 Crossroads Circle, Waukesha, WI 53187-1612
9. Publisher: Brian Schmidt, 21027 Crossroads Circle, Waukesha, WI 53187-1612

Editor: David Eicher, 21027 Crossroads Circle, Waukesha, WI 53187-1612

10. Owner: Kalmbach Media Co., 21027 Crossroads Circle, P.O. Box 1612, Waukesha, WI 53187-1612. Stockholders owning or holding 1 percent or more of total amount of stock are: Deborah H.D. Bercot, 22012 Indian Springs Trail, Amberson, PA 17210; Gerald and Patricia Boettcher Trust, 8041 Warren Ave., Wauwatosa, WI 53213; Sally Darragh, 145 Prospect Ave., Waterloo, IA 50703; Melanie J. Duval Trust, 3253 Halverson Way, Roseville, CA 95661; Harold Edmonson, 6021 N. Marmora Ave., Chicago, IL 60646-3903; Laura & Gregory Felzer, 3328 S. Honey Creek Dr., Milwaukee, WI 53219; Susan E. Fisher Trust, 3430 E. Sunrise Dr., Ste. 200, Tucson, AZ 85718; Bruce H. Grunden, 7202 Wild Violet Dr., Humble, TX 77436; Linda H. Hanson Trust, P.O. Box 19, Arcadia, MI 49613; George F. Hirschmann Trusts, P.O. Box 19, Arcadia, MI 49613; Susan E. Ingles Trust, 2604 Oakcrest Dr., Waukesha, WI 53188; Charles & Lois Kalmbach, 7435 N. Braeburn Ln., Glendale, WI 53209; Kalmbach Profit Sharing/401K Savings Plan & Trust, P.O. Box 1612, Waukesha, WI 53187-1612; Elizabeth King Trust, U.S. Bank, 777 E. Wisconsin Ave., Milwaukee, WI 53202; William J. King Estate, 4816 Washburn Ave. S., Minneapolis, MN 55410; Mahnke Family Trust, 4756 Marlborough Way, Carmichael, CA 95608; Milwaukee Art Museum, Inc., 700 N. Art Museum Dr., Milwaukee, WI 53202; Cynthia Darragh Oatman, 1708 Roxborough Rd., Unit E, Charlotte, NC 28211; Mary K. Szalanski, 3355 S. Ann Louise Dr., New Berlin, WI 53146; Lois E. Stuart Trust, 1320 Pantops Cottage Ct. #1, Charlottesville, VA 22911-4663; David M. Thornburgh Trust, 8877 Collins Ave., Unit 307, Surfside, FL 33154.

11. Known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities: None.

12. Tax status (for completion by nonprofit organizations authorized to mail at nonprofit rates): Has not changed during preceding 12 months

13. Publication title: ASTRONOMY

14. Issue date for circulation data below: September 2021

15. Extent and nature of circulation:	Average no. copies each issue during preceding 12 months	No. copies of single issue published nearest to filing date
a. Total number of copies (net press run)	107,242	107,096
b. Paid circulation (by mail and outside the mail)		
1. Mailed outside-county paid subscriptions	72,392	71,849
2. Mailed in-county paid subscriptions	-0-	-0-
3. Paid distribution outside the mails including sales through dealers and carriers, street vendors, counter sales, and other paid distribution outside USPS	6,621	5,913
4. Paid distribution by other classes of mail through the USPS	-0-	-0-
c. Total paid distribution [sum of 15b (1), (2), (3), and (4)]	79,013	77,762
d. Free or nominal rate distribution (by mail and outside the mail)		
1. Outside-county	-0-	-0-
2. In-county	-0-	-0-
3. Other classes mailed through the USPS	219	219
4. Outside the mail	-0-	-0-
e. Total free or nominal rate distribution [sum of 15d (1), (2), (3) and (4)]	219	219
f. Total distribution (sum of 15c and 15e)	79,232	77,981
g. Copies not distributed	28,010	29,115
h. Total (sum of 15f and g)	107,242	107,096
i. Percent paid (15c divided by 15f times 100)	99.72%	99.72%
16. Electronic copy circulation:		
a. Paid electronic copies	4,522	4,158
b. Total paid print copies (15c) plus paid electronic copies (16a)	83,536	81,921
c. Total print distribution (15f) plus paid electronic copies (16a)	83,755	82,140
d. Percent paid, both print and electronic (16b divided by 16c times 100)	99.74%	99.73%

17. Publication of Statement of Ownership:

Publication required. Printed in the January 2022 issue of this publication.

18. I certify that all information furnished on this form is true and complete.

Nicole McGuire, Senior Vice President, Consumer Marketing. Date: September 28, 2021.

INDEX *of* ADVERTISERS

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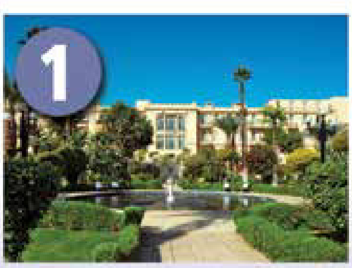

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